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AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 1991/92 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
Jane Rosenberg and Roger Hewitt

May 1992

ADMINISTRATIVE REPORT LJ-92-17

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U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center
P.O. Box 271
La Jolla, CA 92038

The U.S. Antarctic Marine Living Resources (AMLR) program provides information needed to formulate U.S. policy on the conservation and international management of resources living in the oceans surrounding Antarctica. The program advises the U.S. delegation to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic treaty system. The U.S. AMLR program is managed by the Antarctic Ecosystem Research Group located at the Southwest Fisheries Science Center in La Jolla.

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BACKGROUND

The long-term objective of the U.S. Antarctic Marine Living Resources (AMLR) field research program is to describe the functional relationships between krill, their environment, and their predators. The field program is based on two working hypotheses: (1) krill predators respond to changes in the availability of their food; and (2) the distribution of krill is affected by both physical and biological aspects of their habitat. In order to refine these hypotheses, a study area was established in the vicinity of Elephant Island (Figure 1). A seasonal field camp was established at Seal Island, off the northwest coast of Elephant Island, where reproductive success and feeding ecology of seal and penguin breeding colonies is monitored. A complementary series of shipboard observations were initiated to describe both within and between season variations in the distributions of nekton, zooplankton, phytoplankton, and water types. In addition, research on aspects of the ecology of Adelie penguins is conducted at Palmer Station each year during the austral summer.

SUMMARY OF 1992 RESULTS

Four surveys were conducted between mid-January and mid-March, 1992. The hydrographic front north of Elephant Island moved offshore as the season progressed. Current flow was generally from the southwest to northeast, with meanders evident north of Elephant Island and intensified flow between Clarence and Elephant Islands. In contrast to the previous season, both phytoplankton biomass and krill abundance decreased from the beginning to the end of the sampling period. Early in the season, phytoplankton biomass was highest south of the hydrographic front and was composed of discoid diatoms, 30-40μm in diameter. Krill were very abundant during the first survey; they were distributed in a band extending across the north side of Elephant Island and wrapping around the western end. By mid-March only a few small areas of high krill density remained northwest of Elephant Island. The size distribution of sampled krill was bimodal: a juvenile mode at 25-30mm and an adult mode at 45mm. The large numbers of juvenile krill and the low numbers of 35-40mm krill suggest successful krill spawning in 1990/91 relative to 1989/90 and 1988/89. The number of chinstrap penguins breeding on Seal Island was the highest ever observed; survival and growth of chicks, however, was only slightly higher than average. Cape petrel reproductive success was particularly good; both breeding and chick survival were above average. The growth rate of fur seal pups was above average as well. At Palmer Station, measures of breeding success suggested that Adelie penguin productivity was higher than last year.

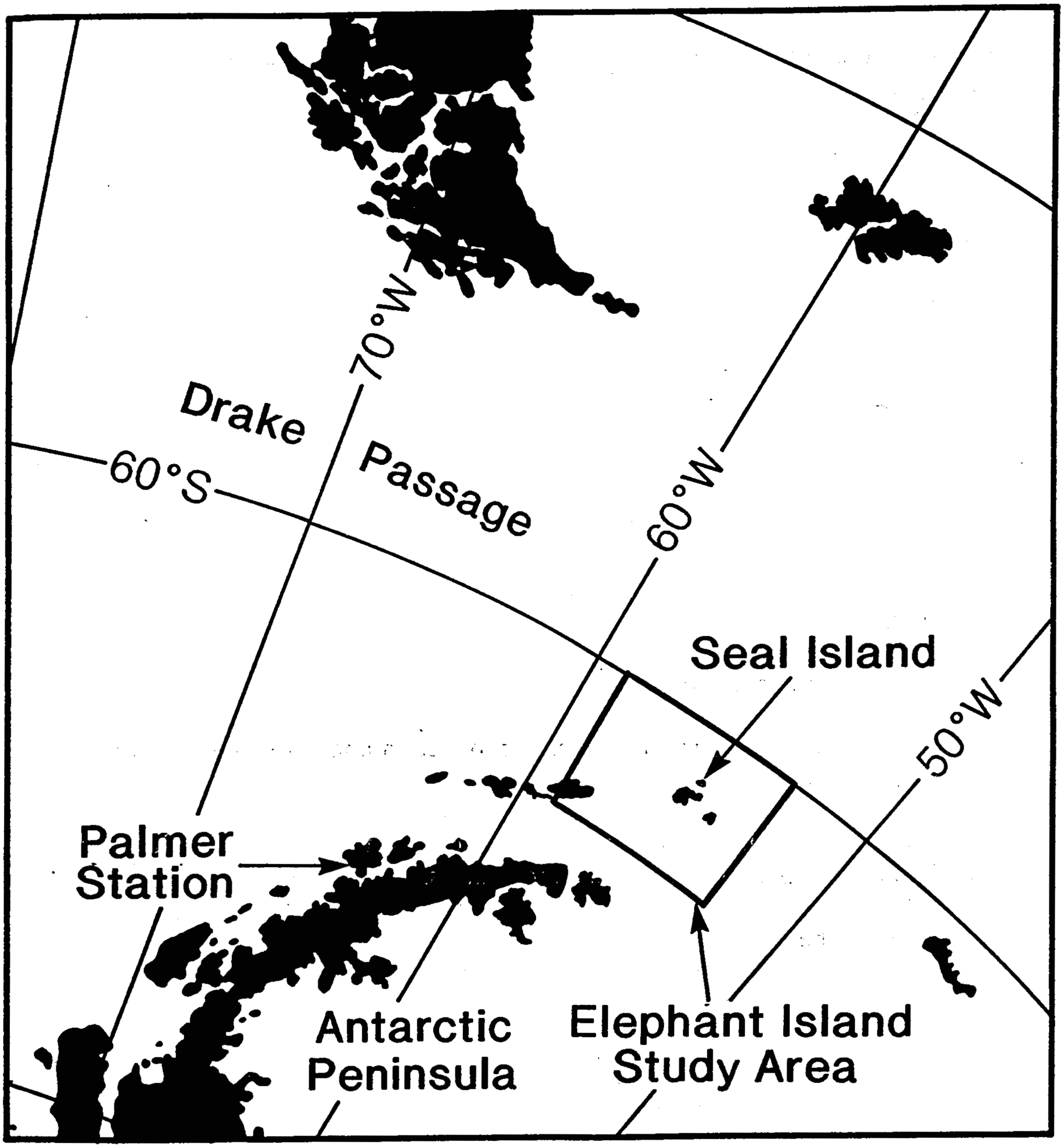

Figure 1. Locations of the U.S. AMLR field research program: Elephant Island Study Area, Seal Island, and Palmer Station.

OBJECTIVES

Shipboard Research:

1. Map meso-scale (10's to 100's of kilometers) features of water mass structure, phytoplankton biomass and productivity, and zooplankton constituents (including krill) in the area around Elephant Island.

2. Estimate the abundance of krill in the area around Elephant Island.

3. Delineate the hydrographic and biological features across the expected front north of Elephant Island.

4. Map the micro-scale (1-10's of kilometers) features of the distribution, density, and abundance of krill immediately north of Elephant Island, within the foraging range of krill predators breeding at Seal Island.

5. Determine vertical and horizontal variations in composition of krill swarms.

6. Measure acoustic target strength of krill as a function of animal size, gender, and sexual maturity.

7. Provide logistic support to Seal Island camp.

8. Determine photosynthetic and bacterial production under various light regimes during northbound transit.

9. Conduct bird and marine mammal observations off the coast of South America during the southbound and northbound transits.

Land-based Research:

<u>Seal Island</u>

1. Monitor pup growth rates and adult female foraging of antarctic fur seals according to CCAMLR Ecosystem Monitoring Program (CEMP) protocols.

2. Conduct directed research on pup production, female foraging behavior, diet, abundance, survival and recruitment of fur seals.

3. Monitor the abundance of all other pinniped species ashore.

4. Monitor the breeding success, fledgling size, reproductive chronology, foraging behavior, diet, abundance, survival, and recruitment of chinstrap and macaroni penguins according to CCAMLR Ecosystem Monitoring Program protocols.

5. Conduct directed research on chick growth and condition, and seasonal patterns in the diving behavior of chinstrap penguins to assess changes in foraging behavior and effort as the breeding season progresses.

6. Assess the reproductive success, survival, and recruitment of cape petrels.

7. Measure the food load delivery to dependent chicks contemporaneously with foraging effort.

8. Measure intra-annual differences in foraging effort in breeding chinstrap penguins.

9. Initiate a feasibility study of the winter foraging behavior and distribution of chinstrap penguins.

Palmer Station:

1. Determine Adelie penguin breeding success.

2. Examine how present and past indices of Adelie penguin breeding success relate to a true measure of breeding success.

3. Gather information on Adelie penguin diet composition and meal size.

4. Determine Adelie penguin chick weights at fledging.

5. Determine the amount of time breeding adult Adelie penguins need to procure food for their chicks.

6. Band a representative sample (1000 chicks) of the Adelie penguin chick population.

7. Determine adult Adelie penguin breeding chronology.

8. Explore the feasibility of adding more of the Standard Methods to the suite of data now being collected at Palmer Station.

DESCRIPTION OF OPERATIONS

Shipboard Research:

Itinerary

Southbound Transit:	Depart Seattle	13 December 1991
	Port call San Diego	18 - 19 December
	Port call at Valparaiso, Chile	6 January 1992
	Arrive Punta Arenas, Chile	12 January
Leg I:	Depart Punta Arenas	15 January
	Re-provision Seal Island	18 January
	Survey A	19 Jan. - 2 February
	Cross-shelf transects	3 - 4 February
	Survey B	5 - 6 February
	Fine-scale MOCNESS sampling	7 - 10 February
	Call at Seal Island	9 February
	Arrive Punta Arenas	13 February
Leg II:	Depart Punta Arenas, Chile	18 February
	Re-provision Seal Island	21 February
	Fur seal pup census	22 -24 February
	Survey C	25 - 28 February
	Inspect Russian F/V	26 February
	Survey D	29 Feb. - 11 March
	Recover Seal Island team	11 March
	Cross-shelf transects	12 March
	Fine-scale acoustic survey	13 -14 March
	Arrive Punta Arenas	18 March
Northbound Transit:	Depart Punta Arenas	21 March
	Port call at Valparaiso	27 March
	Phytoplankton studies	28 March - 14 April
	Port call at San Diego	15 April - 16 April
	Arrive Seattle	22 April

Leg I.

1. The *Surveyor* took her departure from South America via the eastern end of the Strait of Magellan. During the transit across Drake Passage, expendable bathythermographs (XBTs) were deployed by personnel from Chile's Servicio Hidrográfico y Oceanográfico de la Armada (SHOA). Land fall was made at Seal Island, and provisions were brought ashore to the AMLR field camp.

2. A large-area survey of 72 Conductivity-Temperature-Depth (CTD)/rosette and net sampling stations, separated by acoustic transects, was conducted (Survey A, Figure 2). Operations at each station included: (1) measurement of temperature, salinity, oxygen, light, transmissometer, and fluorescence profiles; (2) collection of discrete water samples at standard depths for analysis of chlorophyll-a content, absorption spectra, particulate organic carbon and nitrogen content, primary production, ATP and DNA content, size fractionation, floristics, and inorganic nutrient content; and (3) deployment of a large plankton net to obtain samples of zooplankton and nekton. Survey operations were interrupted for two medical evacuations, and the last line of planned stations (A65 through A72) was dropped in order to save time.

3. Based on results from the large-area survey, two series of cross-shelf transects were conducted (Figure 3). Station operations were the same as described above; acoustic data were also collected between stations.

4. A small-area acoustic survey was conducted to the north of Elephant Island (Survey B, Figure 4). The survey was conducted at a ship's speed of 10 knots over a 2-day period with no CTD/rosette or net sampling stations.

5. Based on the results of the small-area survey, fine-scale MOCNESS sampling was conducted in four areas of high krill density (Figure 5). The sampling effort was directed by simultaneous acoustic observations. CTD/rosette casts were also conducted in the four areas.

6. Continuous underway measurements included ship's position, true wind speed and direction, air temperature, relative humidity, barometric pressure, light levels at several spectra, sea surface water temperature, salinity, light beam transmission, and fluorescence.

Leg II.

1. The *Surveyor* took the same route as Leg I from Punta Arenas to Seal Island. A series of XBTs were conducted while in transit across Drake Passage at the request of SHOA. Fresh provisions and mail were transferred to the field camp at Seal Island.

2. A census of fur seal and penguin rookeries was conducted on several islands in the vicinity of Elephant and Livingston Islands. Census teams were deployed from the *Surveyor* and the Chilean R/V *Alcazar*.

3. A small-area acoustic survey was conducted to the north of Elephant Island (Survey C, Figure 4). Three IKMT net samples were collected at designated areas of large krill concentrations. Inclement weather prevented additional samples from being taken.

4. A Russian krill fishing vessel was inspected under the guidelines of the CCAMLR Inspection Program.

5. A large-area survey, similar to Survey A above, was completed around Elephant, Clarence and Gibbs Islands (Survey D, Figure 2).

6. Four acoustic, net sampling and CTD cross-shelf transects were completed across the shelf break north of Elephant Island at various times during the leg.

7. A fine-scale acoustic survey (1 mile by 1 mile with approximately 0.1 mile transect spacing) was conducted west of Elephant Island. The survey pattern was occupied seven times over a 48-hour period.

8. Continuous underway measurements were similar to those recorded during Leg I.

Northbound Transit.

1. CTD/rosette casts were made to obtain vertical profiles of temperature, salinity, dissolved oxygen, light transmission, solar irradiance, and chlorophyll-a fluorescence. Continuous underway measurements included ship's position, true wind speed and direction, air temperature, relative humidity, barometric pressure, light levels at several spectra, sea surface water temperature, salinity, light beam transmission, and fluorescence.

2. Water samples were collected from Niskin bottles and incubated under various ultraviolet light conditions. Water samples were also retained for determination of chlorophyll-a content, inorganic nutrients, photosynthetic pigments, and species composition of the phytoplankton.

3. Bacterial production was measured under various visible and ultraviolet light conditions. Water samples were collected to determine vertical profiles of bacteria and viruses. Experiments were conducted to determine diurnal variation in bacterial activity and possible toxic effects of polyethylene bags on bacterial production.

4. Underway observations of marine mammals and birds were collected.

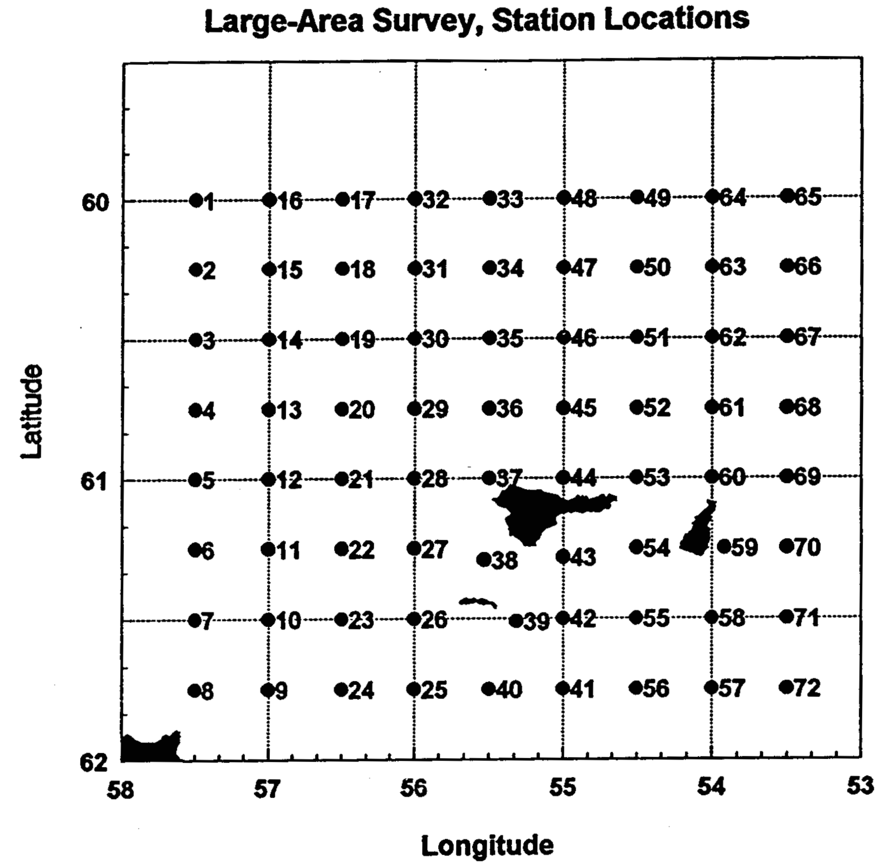

Figure 2. Large-area survey station locations (Surveys A and D).

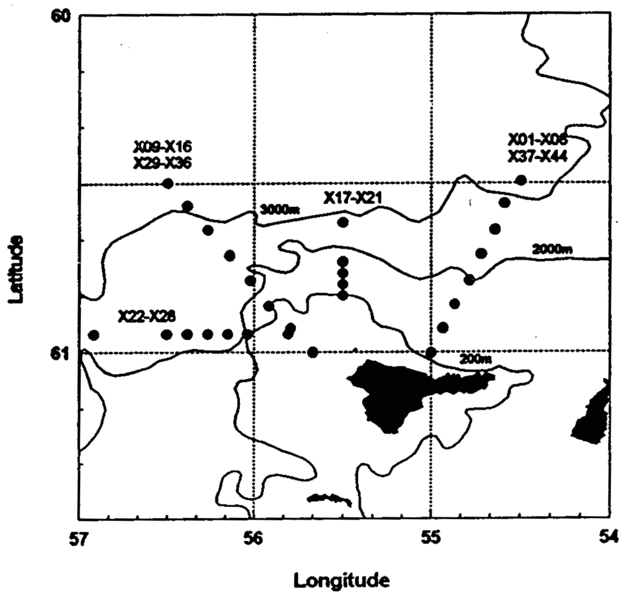

Figure 3. Cross-shelf transects station locations.

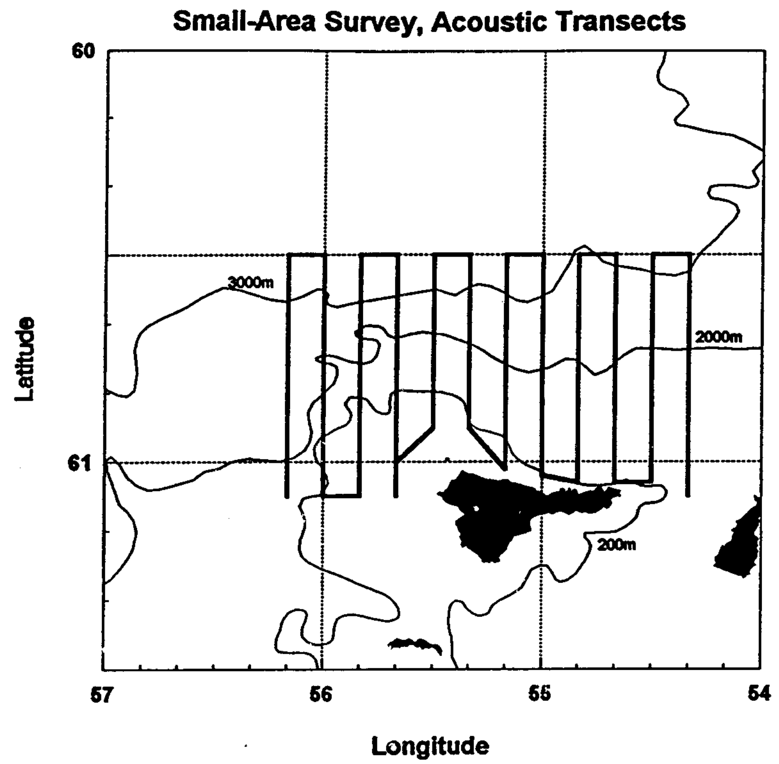

Figure 4. Small-area survey acoustic transects (Surveys B and C).

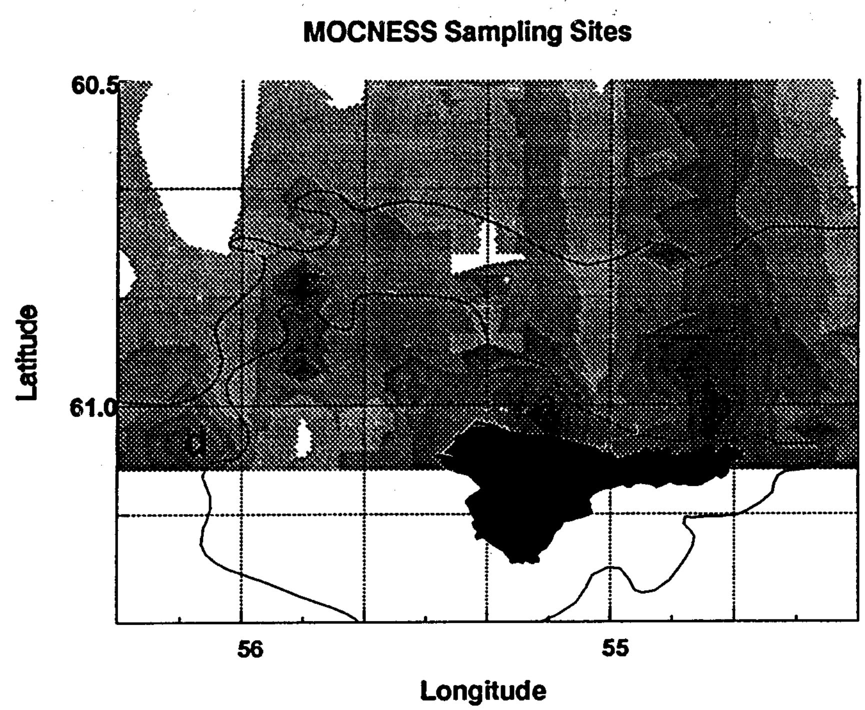

Figure 5. Distribution of krill and MOCNESS sampling areas a, b, c, and d.

Land-Based Research:

Seal Island

1. The four person field team (P. L. Boveng, M. E. Goebel, J. K. Jansen, and S. W. Manley) arrived at Seal Island on 2 December 1991. The *Surveyor* disembarked two additional team members (D. A. Croll and H. D. Douglas) and supplies on 18 January 1992. The field team reactivated field camp.

2. Radio-transmitters were attached to 40 female fur seals in early December in order to study attendance ashore. Sixteen of the 40 females were instrumented with time-depth recorders (TDRs) to study foraging behavior.

3. Fur seal pup weights were monitored from late December to late February. Daily counts of live and dead pups were collected. Counts of all fur seals present were made at weekly intervals. Daily observations were made of fur seals tagged in this and previous years to assess survival and recruitment.

4. Fur seal feces were collected at bi-weekly intervals for analysis of diet.

5. Weekly censuses of other pinnipeds were conducted.

6. *Surveyor* embarked M. E. Goebel and C. Shin, a visiting Korean scientist, on 10 February. *Surveyor* returned on 21 February to offload supplies and embark D. A. Croll to conduct fur seal census. Croll was returned to island on 25 February.

7. Daily radio communications were maintained with Palmer Station prior to the arrival of the *Surveyor* in the study area. After that, communications were maintained with the *Surveyor*, biologists at various antarctic science stations, the R/V *Alcazar*, and the M/V *World Discoverer*.

8. An automatic weather station was installed in December, including a variety of weather sensors. Data were downloaded once a week for analysis by Texas A & M researchers.

9. Breeding success of chinstrap and macaroni penguins was estimated according to CEMP Standard Methods.

10. A total of 40 adult chinstrap penguins were instrumented with radio transmitters to monitor the duration of foraging trips. Forty-two chinstrap penguins were equipped with TDRs to provide information on diving behavior.

11. Thirty stomach content samples of chinstrap penguins were collected for diet studies.

12. The number of breeding pairs of all penguin colonies on the island was counted. Three censuses were made of 10 geographically discrete chinstrap colonies undisturbed by other activities. Four macaroni penguin colonies were also censused.

13. To estimate annual survivorship and recruitment into the breeding population, 2000 chinstrap and 75 macaroni penguin chicks were banded.

14. The growth rates of chinstrap penguin chicks were monitored by measuring the weight, culmen length, culmen depth, wing length, and noting status of juvenile plumage.

15. In order to study food load delivery to chinstrap penguin chicks, three nests were equipped with automatic weighing systems. As adults returned to the nest to feed their young, their mass was automatically recorded.

16. The breeding success of cape petrels was estimated by surveying nests five times during the season.

17. A study was initiated to test the feasibility of attaching TDRs equipped with location sensors to penguins during the non-breeding season.

Palmer Station

1. One hundred Adelie penguin nests were followed on Humble Island from clutch initiation to creche.

2. On 9 January, the proportion of 1 and 2 Adelie penguin chick broods was assessed at 51 colonies in 5 different rookeries; on 26 January these and other colonies were censused to assess chick production.

3. Adult Adelie penguins were captured and lavaged (stomach pumping using a water off-loading method) for diet composition studies.

4. Adelie penguins chicks were weighed during fledging at beaches near the Humble Island rookery.

5. Adelie penguins were instrumented with radio receivers and automatic data loggers at the Humble Island rookery between 15 January and 23 February to monitor presence-absence data.

6. One-thousand Adelie chicks were banded as part of long-term demographic studies at AMLR colonies on Humble Island.

SCIENTIFIC PERSONNEL

Cruise Leader:
- Roger Hewitt, Southwest Fisheries Science Center (Leg I)
- Rennie Holt, Southwest Fisheries Science Center (Leg II)
- Osmund Holm-Hansen, Scripps Institution of Oceanography (Northbound Transit)

Physical Oceanography:
- Anthony Amos, University of Texas at Austin (Leg II, Northbound Transit)
- Margaret Lavender, University of Texas at Austin (Legs I and II)
- Jeff Heimann, University of Texas at Austin (Leg I)

Phytoplankton:
- Walter Helbling, Scripps Institution of Oceanography (Legs I and II, Northbound Transit)
- Virginia Villafañe, Scripps Institution of Oceanography (Leg I)
- Livio Sala, Univ. Nacional de la Patagonia, Argentina (Legs I and II)
- Wanda Garcia, Universidad Católica, Chile (Legs I and II)
- William Cochlan, Scripps Institution of Oceanography (Leg II, Northbound Transit)
- Stella Casco, Univ. Nacional de la Patagonia, Argentina, (Northbound Transit)

Krill and Zooplankton Sampling:
- Valerie Loeb, Moss Landing Marine Laboratories (Leg I)
- John Wormuth, Texas A&M University (Leg I)
- Volker Siegel, Sea Fisheries Research Institute, Germany (Leg I)
- Marilyn Yeager, Texas A&M University (Leg I)
- Luiz Fernandes, Texas A&M University (Leg I)
- Karen Davis, Moss Landing Marine Laboratories (Leg II)
- Dennis Kelly, Orange Coast College (Leg II)
- Frank Roddy, Moss Landing Marine Laboratories (Leg II)

Hydroacoustic survey:
- David Demer, Scripps Institution of Oceanography (Leg I)
- Jane Rosenberg, Southwest Fisheries Science Center (Leg I)
- Duncan McGehee, Scripps Institution of Oceanography (Leg II)
- Stephanie Sexton, Southwest Fisheries Science Center (Leg II)

Marine Mammal and Bird Observations:
- Tim Cole, College of the Atlantic (Southbound Transit, Legs I and II, Northbound Transit)
- David Ainley, Point Reyes Bird Observatory (Northbound Transit)
- Larry Spear, Point Reyes Bird Observatory (Northbound Transit)

Drake Passage transect and PAH Sampling:
- Rebeca D. Guesalaga, Serv. Hydro. y Ocean. de la Armada, Chile (Leg I)
- Christian B. Anwandter, Serv. Hydro. y Ocean. de la Armada, Chile (Leg II)

Seal Island Field Team:

- Peter Boveng, National Marine Mammal Laboratory
- Donald Croll, National Marine Mammal Laboratory
- Michael Goebel, National Marine Mammal Laboratory
- John Jansen, National Marine Mammal Laboratory
- Scott Manley, National Marine Mammal Laboratory
- Hector Douglas, National Marine Mammal Laboratory
- C. Shin, Korean Antarctic Research Program

Chilean Research Vessel *Alcazar*:

- John Bengtson, National Marine Mammal Laboratory
- Peter Boveng, National Marine Mammal Laboratory
- Anders Modig, Stockholm University
- Daniel Torres-N., Instituto Antarctico Chileno
- Anelio Aguayo, Instituto Antarctico Chileno

Palmer Station:

- William Fraser, Old Dominion University
- Wayne Trivelpiece, Old Dominion University
- Brent Houston, Old Dominion University
- Donna Patterson, Old Dominion University
- David Keller, Old Dominion University

DETAILED REPORTS

1. Physical Oceanography; submitted by A. F. Amos, M. K. Lavender, and J. K. Heimann, University of Texas at Austin, Marine Science Institute.

1.1 Objectives: The physical oceanography component of the AMLR program provides information on the hydrography of the upper water column with the objective of assessing its influence on the observed distribution of krill (*Euphausia superba*). By making closely spaced CTD/rosette casts, the water masses of the Elephant Island region can be identified, and the mean current flow deduced. This component also records the meteorological and sea surface conditions continuously while the *Surveyor* is in the study region to study the effect of atmospheric conditions on the upper-water-layer structure. AMLR 1992 is the third field season for the collaboration of physical measurements with biological studies.

1.2 Accomplishments:

CTD/Rosette Stations: One hundred and eighty-eight (188) CTD/rosette casts were made during AMLR 1992. The cruise was divided into two legs; stations done during Leg I were re-occupied during Leg II about one month later. The large-area survey of 72 stations (Figure 2--Introduction), which was on a quarter degree latitude by half-degree longitude grid (approximately 24km square), was the major CTD survey of AMLR 1992. Due to medical emergencies diverting the ship, only 64 stations of the grid were done during Leg I; the eastern-most line on meridian 53°30'W was omitted. Two cross-shelf transects of closely-spaced CTD stations were made north of Elephant Island on each leg to define the boundary of the shelf-break oceanographic front discovered on previous AMLR cruises (Figure 3--Introduction). Time allowed us to complete two additional cross-shelf transects to augment the planned cross-shelf study. Finally, eight CTD/rosette casts were done in conjunction with the MOCNESS tows.

Following the convention established on previous AMLR cruises, the large-area survey stations were designated "A" (A01 through A64) on Leg I, and "D" (D01 through D72) on Leg II. Cross-shelf transects and any extra stations were designated "X" (X01 through X16 on Leg I, and X17 through X44 on Leg II). The fine-scale MOCNESS sampling stations were designated "M" (M02, M04, M06, M07, M10, M12, M15, and M18 on Leg I only).

Almost two thousand water samples were collected from the rosette bottles. Water samples were collected for determination of micronutrient, phytoplankton, chlorophyll, and salinity content. Salinity data were analyzed on board (using a Guildline Autosal) by *Surveyor's* survey technicians to verify the depth that each bottle tripped and to provide calibration data for the CTD conductivity sensor. On both legs, expendable bathythermographs (XBTs) were deployed during the acoustic surveys where time did not permit CTD/rosette casts to be made. Additional XBT drops were done across the

Drake Passage on both southbound transits to provide the Servicio Hidrográfico y Oceanográfico de la Armada with information on the Antarctic Polar Front. Some XBTs for these projects were provided by the University of Texas Marine Science Institute (UTMSI) and some by *Surveyor*.

Underway environmental observations: Sixty-three days of weather, sea temperature, salinity, clarity, chlorophyll, and solar radiation data were continuously collected during AMLR 1992. Augmented with the ship's navigational information, these data provided complete coverage of surface environmental conditions encountered throughout the cruise. A University of Texas Zeno (Coastal Climate Co.) weather station was installed by the Seal Island party on the hill above the Seal Island camp. Records have been recovered from the instrument for the period 14 Dec 1991 through 06 March 1992 (83 days). The weather station was left in place on Seal Island to provide a year-round record of weather conditions there. Data were provided to *Surveyor* whenever the ship visited the island to provide comparison with ship's underway weather data.

1.3 Methods:

CTD/Rosette: The water column was sampled continuously with a Sea-Bird Electronics SBE-9 CTD. CTD/rosette casts were limited to 750 meters (m) depth (or to within a few meters of the ocean floor when the depth was less than 750m). A Benthos 12-kHz pinger was attached to the rosette frame. A Sea-Bird dissolved oxygen sensor, Seatech 25-cm beam transmissometer, a Biospherical Instruments PAR sensor, and a Seatech *in situ* fluorometer provided additional water column data on each station. A standard General Oceanics RMS Mk VI rosette sampler with eleven 10-liter bottles was used to collect the water samples. The space usually occupied by the twelfth bottled was used to mount the PAR sensor which requires a clear field of view of the downwelling light. All Niskin bottles had teflon coated springs to minimize contamination of the sample. CTD data were collected using a Data World 25 MHz 386 PC and stored on Bernoulli 44 megabytes (MB) removable disk cartridges.

The CTD was lowered at a rate of 50m/min with a sampling rate of 24 scans per second and raised at a rate of 60-75m/min with a sampling rate of 6 scans per second. Rosette bottles were triggered at the bottom (usually 750m) and then at pre-determined levels as the instrument was brought to the surface. Triggering the rosette did not interfere with the flow of CTD data as a three-conductor electromechanical cable was used. Data from each sensor are recorded on "Mark" files at the moment the bottle is triggered. At stations shallower than 750m, the pinger was used to guide the instrument to within 5-10 meters of the ocean floor. The cross-shelf transect stations were taken to the bottom or 2000m, whichever was shallower. For these, the fluorometer and PAR sensors had to be removed due to their pressure-case limitations.

CTD data were processed on board ship using Sea-Bird's software to produce files with data averaged over 1-m depth bins. A series of programs developed by the principal investigator were then used to perform dynamic computations, generate Temperature/Salinity (T/S) curves and property-property diagrams, and conduct a preliminary analysis of the data. These data were provided to other AMLR scientists for their initial analyses. No attempt was made to apply salinity corrections to these data. Comparison of the Autosal salinities with those from the CTD showed an offset of about 0.020 $^{\circ}/_{\infty}$. Many of the sample depths are within high temperature and salinity gradients and are not suitable for this type of calibration. A detailed analysis of these differences must be done before the final corrections are made.

Underway data: Data from twelve environmental sensors were collected, multiplexed, and combined with the GPS navigation information. Ship's position and environmental data were acquired from the *Surveyor's* ETHERNET LAN using a program (LOGUNDER) and the ship's Everex 386 computer. This provided GPS position, ship's course and speed, relative wind speed and direction, air temperature (from a Coastal Climate Weatherpak), and sea temperature and salinity from the ship's Sea-Bird SBE-21 thermosalinograph. Using a Weathermeasure signal-conditioning unit, barometric pressure, air temperature, relative humidity, and sea-surface temperature (from a towed thermistor) data were sent to a Hewlett-Packard 3421A data acquisition unit where they were multiplexed and sent to the Data World computer via IEEE-488 GPIB interface.

Three optical sensors, an Eppley PSP pyroheliometer, a Bisospherical Instruments PAR sensor, and an Eppley TUVR sensor, were mounted on the flying bridge to sense solar radiation relatively unobstructed by *Surveyor's* superstructure and masts. These data were fed directly to the HP multiplexer. Finally, a plumbed sea-water flow-through system provided bubble-free water for a Seatech 25-cm transmissometer and a Turner Designs fluorometer to monitor sea-surface water clarity and chlorophyll fluorescence. The inputs were also fed to the HP 3421A.

Because of problems with the direct GPIB interface, these underway data were sent to the computer using a National Instruments GPIB/RS 232 controller (Leg II only). Data were collected at one-minute intervals throughout both legs. On Leg II, a Hewlett-Packard 7475A plotter was used to provide real-time graphical representation of environmental conditions. Daily logs and plots of the data were provided to AMLR investigators and the ship's navigator.

1.4 Preliminary Results and Analysis:

Water masses: From previous AMLR cruises we have recognized several water mass types in the Elephant Island region, designated types I through V. They have been classified by their T/S curve from the surface to 750m.

TYPE I — Drake Passage water: warm, low salinity water, strong sub-surface temperature minimum ("Winter Water," approximately -1°C; salinity 34.0 ppt.), a temperature maximum at the core of the Circumpolar Deep Water (CDW) near 500 meters.

TYPE II A transition water: temperature minimum near 0°C, isopycnal mixing below T-min, CDW evident at some locations.

TYPE III Weddell-Scotia Confluence: little evidence of a temperature minimum, mixing with Type II, no CDW, temperature at depth generally > 0°C.

TYPE IV Eastern Bransfield Strait water: deep temperature near -1°C, salinity 34.5 ppt, cooler surface temperatures.

TYPE V Weddell Sea water: little vertical structure, cold surface temperatures (near or below 0°C).

These are broad classifications involving the entire water column as shown in the insets of Figure 1.1, which also shows the approximate boundaries of the water masses from Leg I of this cruise. In assessing the relationship between these water mass types and the distribution of krill, it may be that the upper 50-100m of the water column is the most important vertical zone. In this case, the major feature in the AMLR area is the abrupt transition between Drake Passage (oceanic) water and Bransfield Strait (shelf) water.

Oceanographically, the Elephant Island zone is bisected by this front. To the north and west, waters of the Drake in summer show the influence of summer warming with surface temperature above 2°, salinity less than 34 $^{o}/_{oo}$ (from melting ice), and a deep mixed layer (often >50m) from the strong winds which prevail in the region. Below the mixed layer, the remnants of the previous winter's surface water form a strong temperature minimum which weakens as the summer progresses. Under this layer, temperature and salinity increase to a maximum of near 2° around 500m, and then slowly decrease to the bottom. The T-max near 500m is the CDW, a water mass which is circumpolar around the continent and is the result of upwelling of water whose origins lie far to the north in the Atlantic Ocean. This year, a dissolved oxygen sensor provided additional information on water mass characteristics; the CDW is depleted in oxygen.

In contrast, the water on the Elephant Island side of the front shows no evidence of CDW, little winter water (although there is a sharp T-min), and higher oxygen despite the depth of almost 1200m at station X39. The transition zone in the front is characterized by mixing of CDW with the more coastal water. Temperature and salinity inversions fall along isopycnal surfaces thus permitting CDW to mix up into the water column. This may be an important mechanism for the vertical transport of krill eggs and larvae north of Elephant Island.

Temporal changes: Leg I took place in the late austral summer and Leg II in the early fall. The contrast was evident in the cooling of surface waters as summer progressed into fall (Figures 1.2a and 1.2b), and in the weakening of the temperature minimum associated with the winter water at depths which ranged below 100m on Leg I to 75m on

Leg II. The change in salinity from $<34^{\circ}/_{oo}$ in the Drake to $>34.3^{\circ}/_{oo}$ west of Clarence Island, is the most evident expression of the front at the ocean surface. On Leg I, a broad area of low salinity extended almost to Elephant Island, and the frontal boundary was diffuse (Figure 1.3a). By late February, the higher salinity water had pushed north and westward, intensifying the salinity gradient along the shelf break (Figure 1.3b). To illustrate the differences in water mass characteristics between the two surveys, miniaturized T/S curves have been plotted on the AMLR 1992 station locations (Figures 1.4a and 1.4b). These "worm" diagrams clearly show the contrast between Drake Passage water to the north of Elephant Island, and Bransfield water to the south. The intrusion and mixing of water on the shelf during Leg II (Figure 1.4b) can be seen in the shape of the T/S curves between 60°30'S and 61°S, west of 56°W. In both seasons, a transition zone is evident at the extreme north of the area, perhaps showing a meander in the Weddell-Scotia Confluence (WSC).

Dynamics: Figures 1.5a and 1.5b show the streamlines of the flow implied from the dynamical calculations from the large-area surveys of Legs I and II. To illustrate, we have used the slope of the sea surface relative to the 500 decibar (db) level. The main axis of the geostrophic flow is from southwest to northeast both in the Drake and the Bransfield. By early March, the flow becomes more complex with meanders and a more easterly component. A concentration of streamlines shows intensified flow between Clarence and Elephant Islands during both legs. It must be emphasized that these are preliminary examinations of the data only, and additional analysis remains to be done.

1.5 Disposition of Data: The CTD/rosette, underway, weather station and XBT data have been stored on Bernoulli 44MB disks. The raw data will be taken to the University of Texas Marine Science Institute in Port Aransas, Texas, U.S.A. Copies of preliminary data, both 1-m averaged CTD and underway data, have been provided to the acoustics and phytoplankton groups.

1.6 Problems and Suggestions: We experienced problems with the ship's Everex computer and some A/C power problems which caused temporary loss of underway data as well as erroneous information that was at first hard to detect. We would like to see a new computer (with math co-processor) for CTD/underway use on future AMLR cruises. The Everex has historically given us problems, especially in interfacing with the GPIB bus and our Bernoulli disk controller on which we rely to store the mass of data collected by this component of AMLR. The *Surveyor's* LAN was a most useful tool to use for temporary data storage and from which to acquire the ship's position and environmental data. The after part of the chart room provided us with excellent space for the CTD lab equipment.

1.7 Acknowledgements: We are grateful for the excellent support provided by *Surveyor* and her crew. Special thanks goes to the ship's electronics technicians who helped out whenever equipment failed and were not once stumped by a problem. The survey technicians did first class service in preparing and launching the CTD and running the endless numbers of salinity samples. Thanks are also due to the survey technicians for helping us out in running extra samples from another project when the R/V *Polar Duke's* salinometer broke down. The winch operators did an excellent job and often in most inclement weather. Finally, we thank the ship's officers who held station and directed the over-the-side work, in particular, LCDR Fred Rossmann and LT John Humphrey who stood 12-hours watches on deck every day during the surveys.

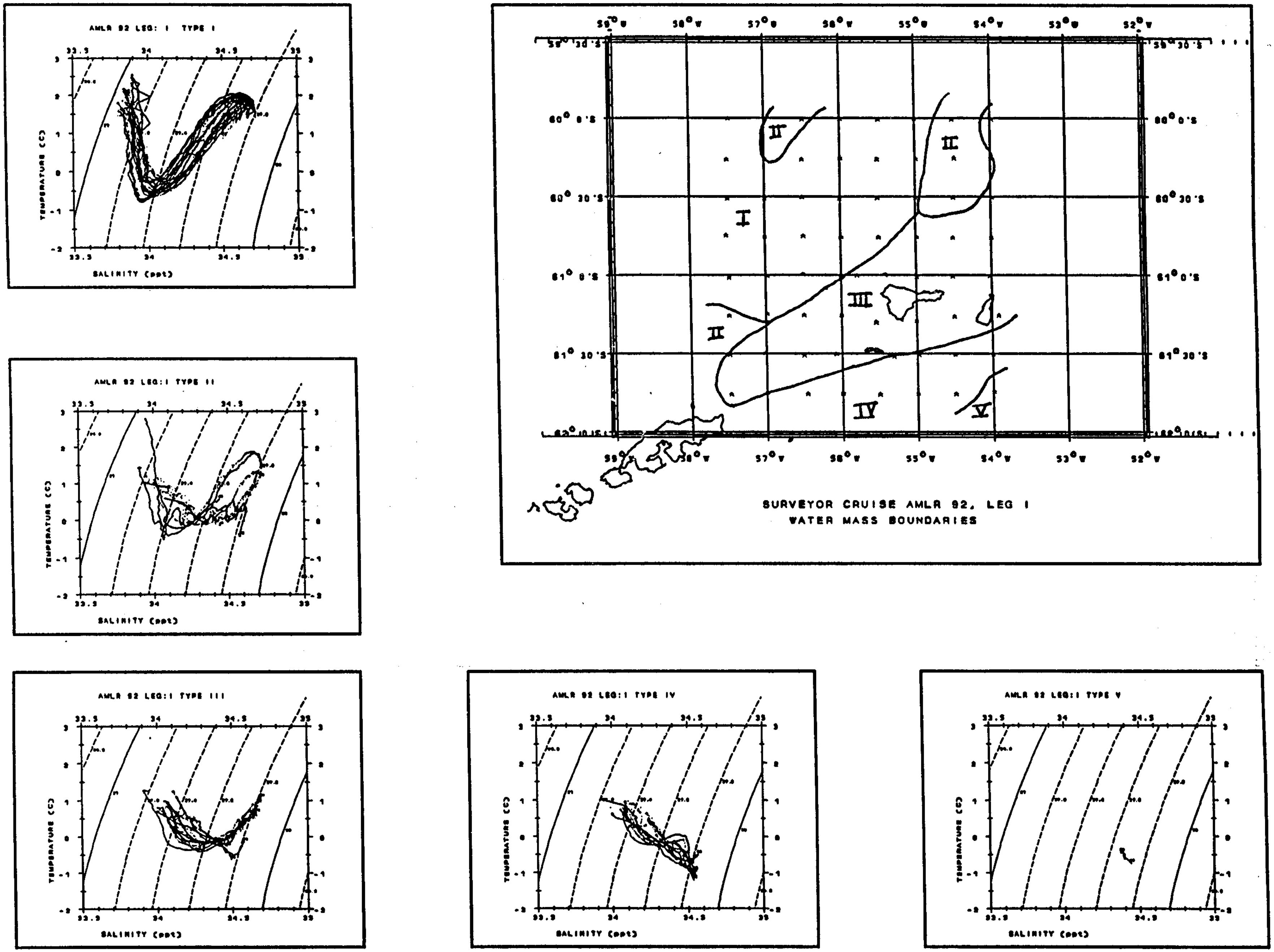

Figure 1.1 Temperature/Salinity characteristics of identified water masses in AMLR study area and approximate water mass boundaries during Leg I.

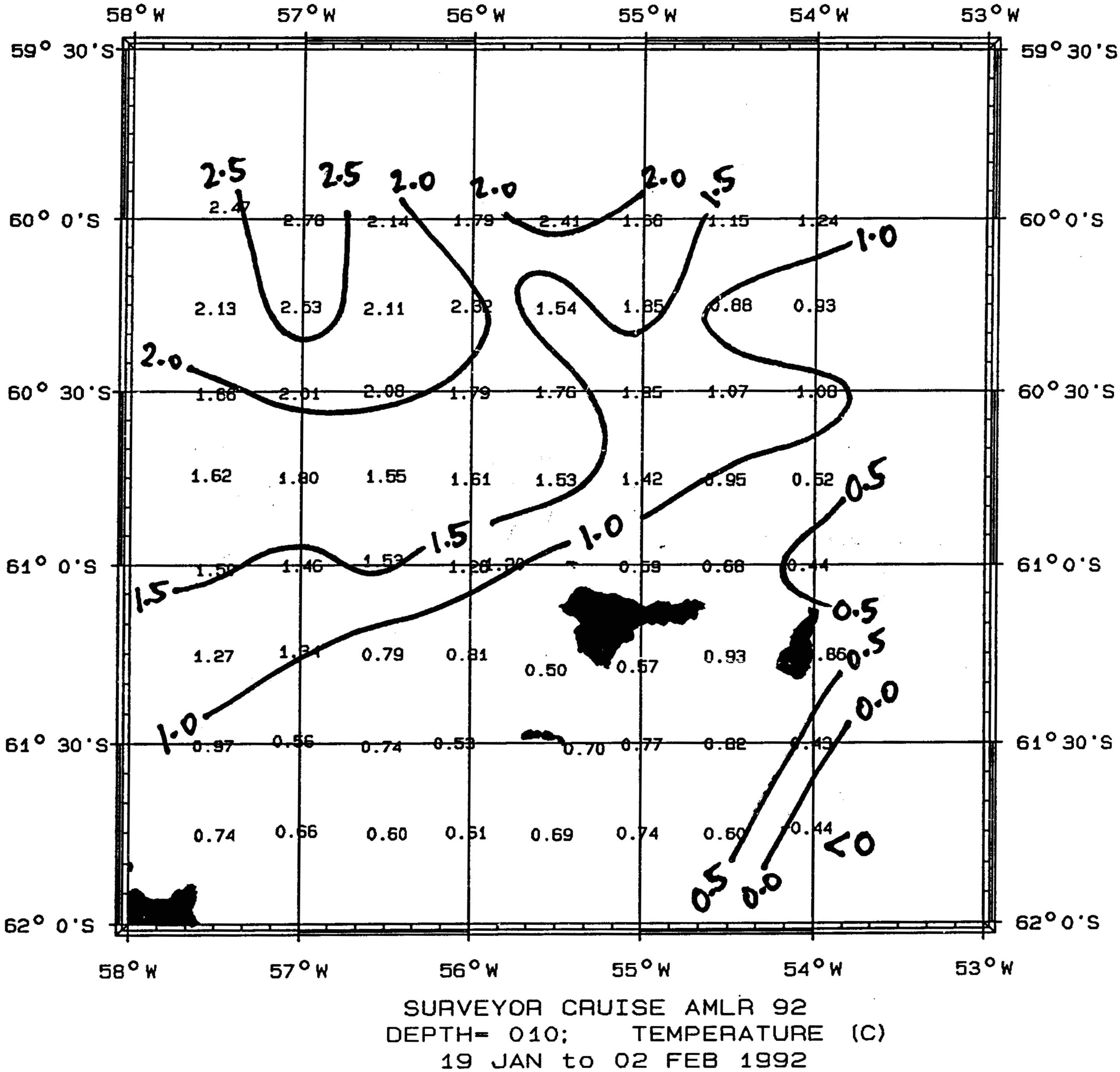

Figure 1.2a Map of near-surface (10m) temperature distribution, Leg I.

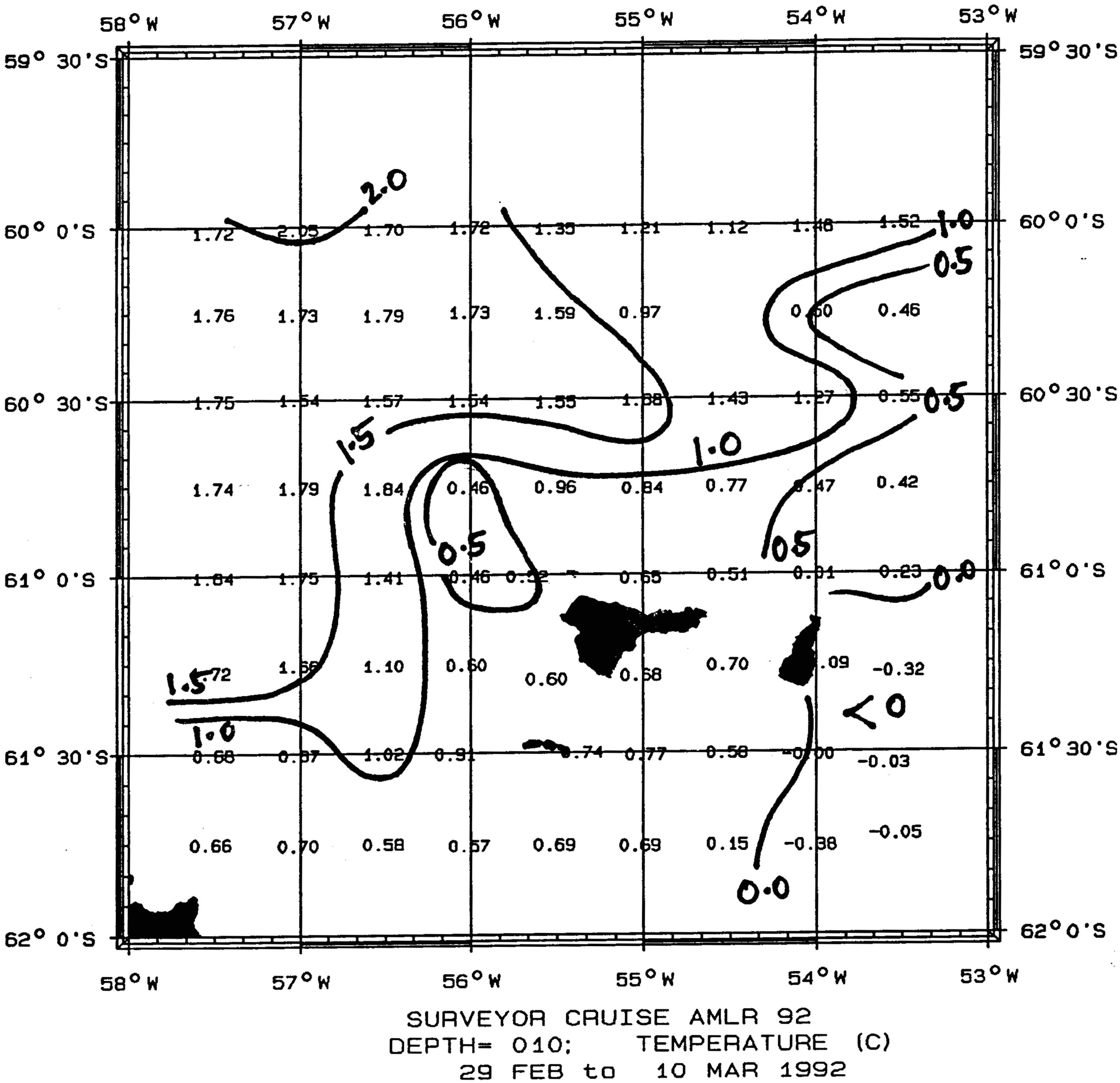

Figure 1.2b Map of near-surface (10m) temperature distribution, Leg II.

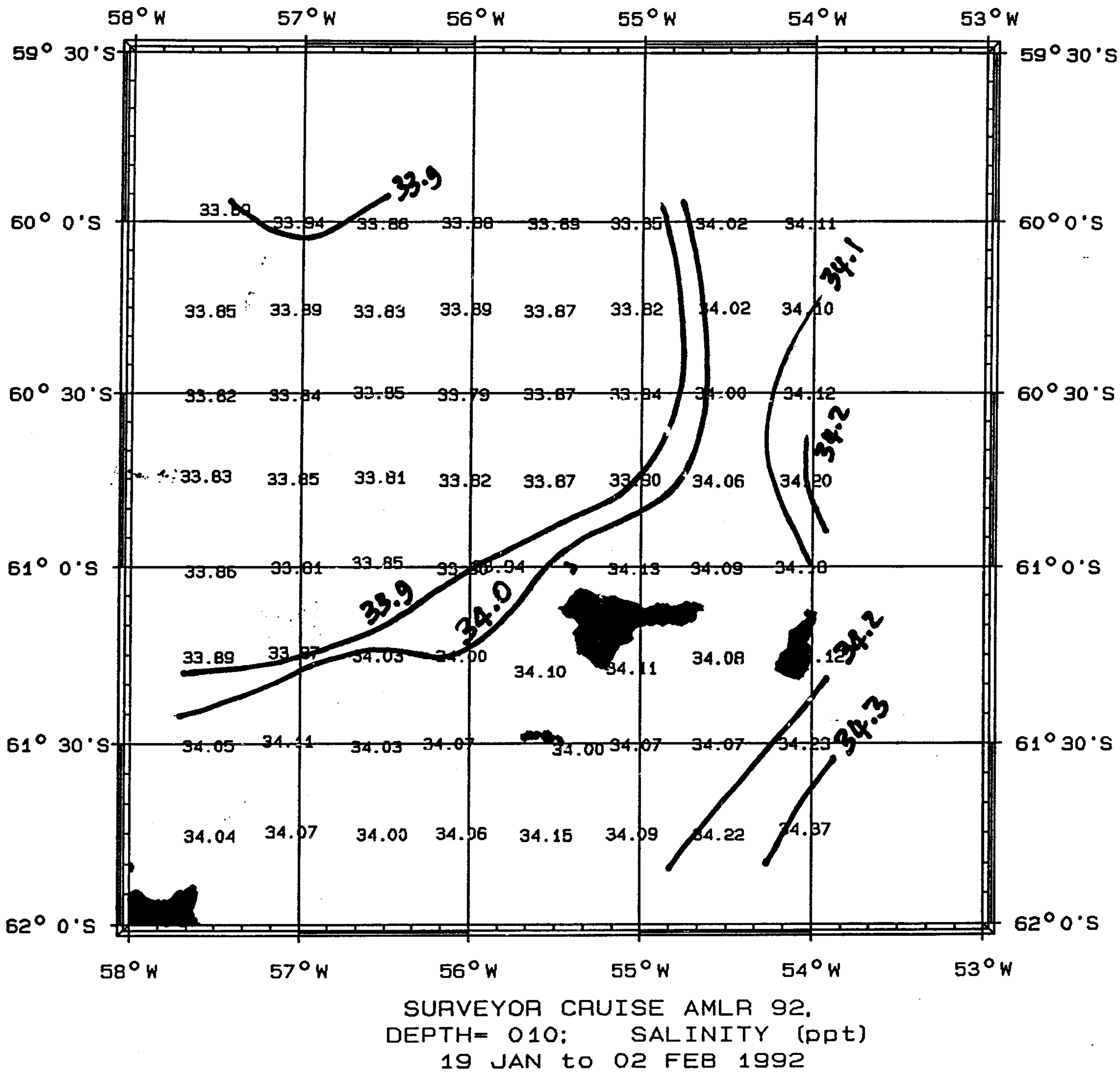

Figure 1.3a Map of near-surface (10m) salinity distribution, Leg I.

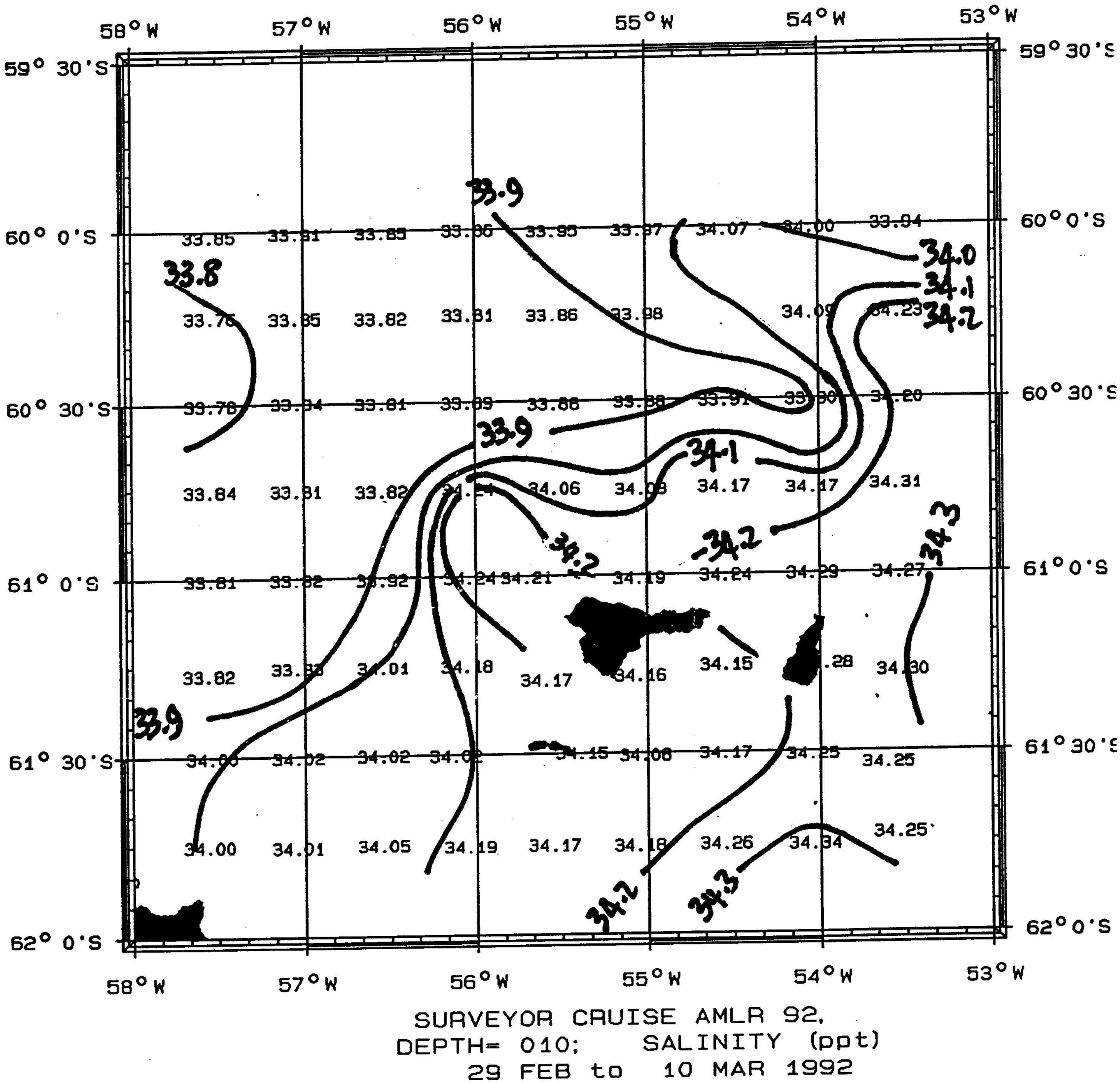

Figure 1.3b Map of near-surface (10m) salinity distribution, Leg II.

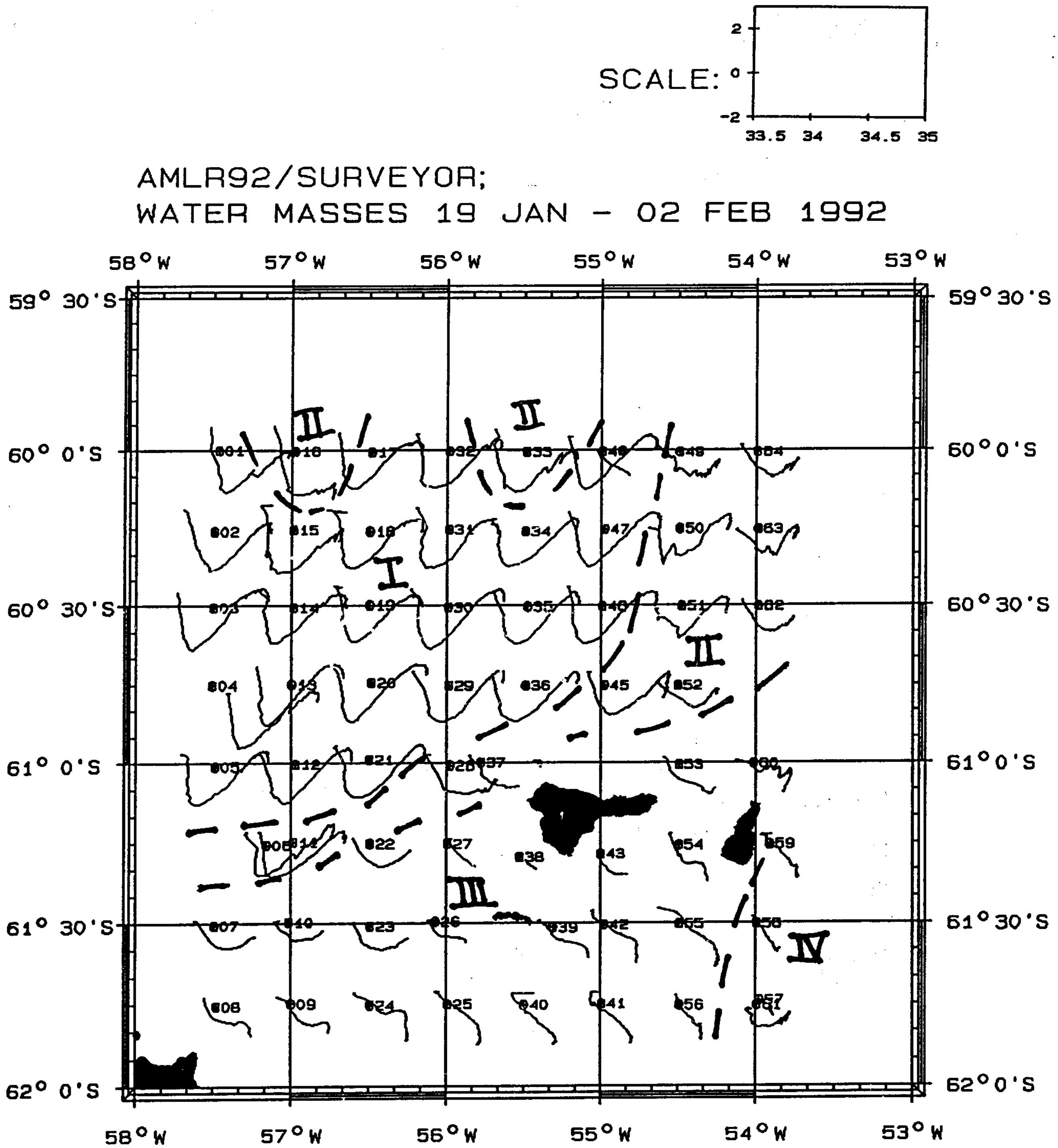

Figure 1.4a Map showing Temperature/Salinity diagrams for large-area survey with approximate water mass boundaries, Leg I.

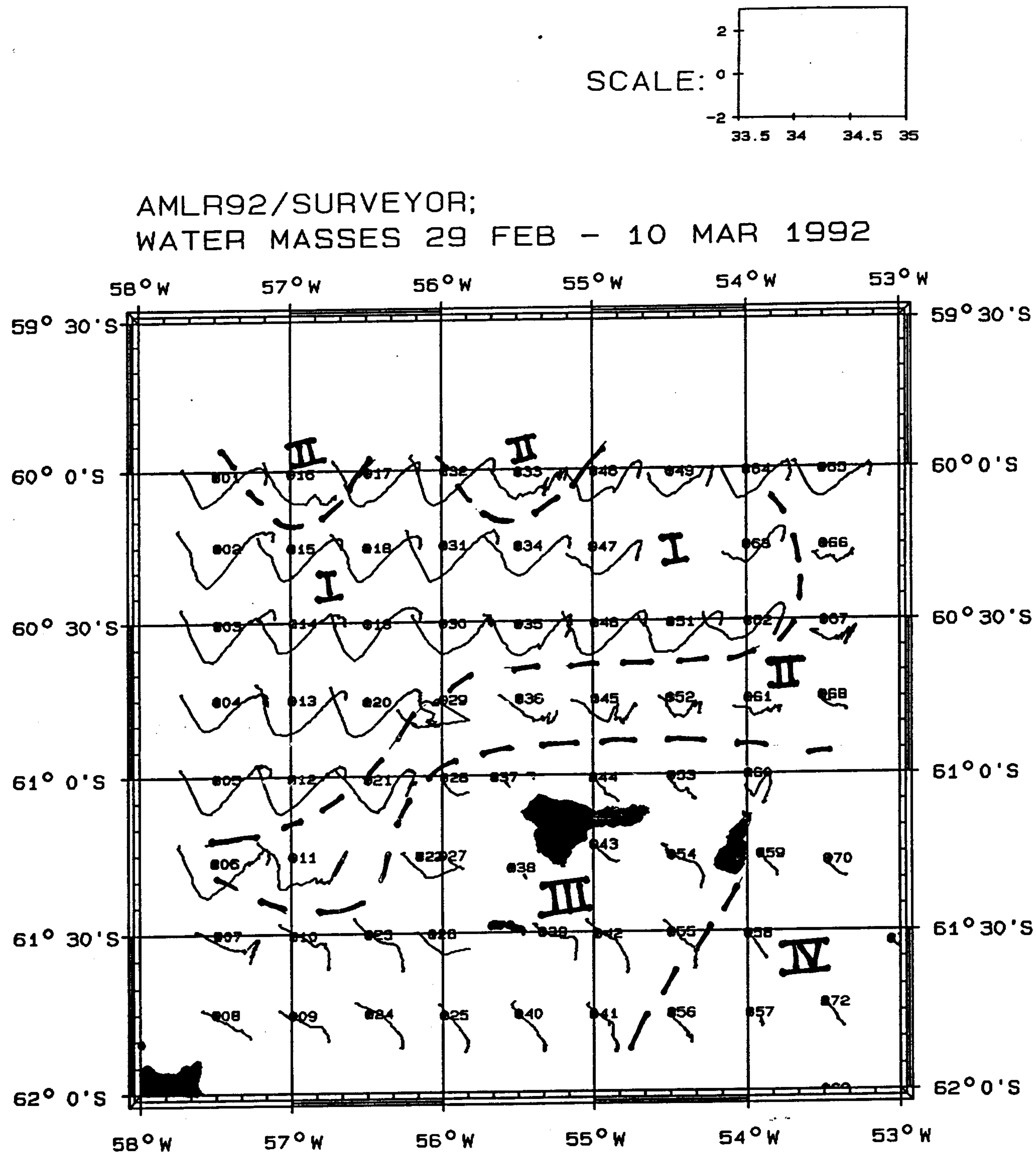

Figure 1.4b Map showing Temperature/Salinity diagrams for large-area survey with approximate water mass boundaries, Leg II.

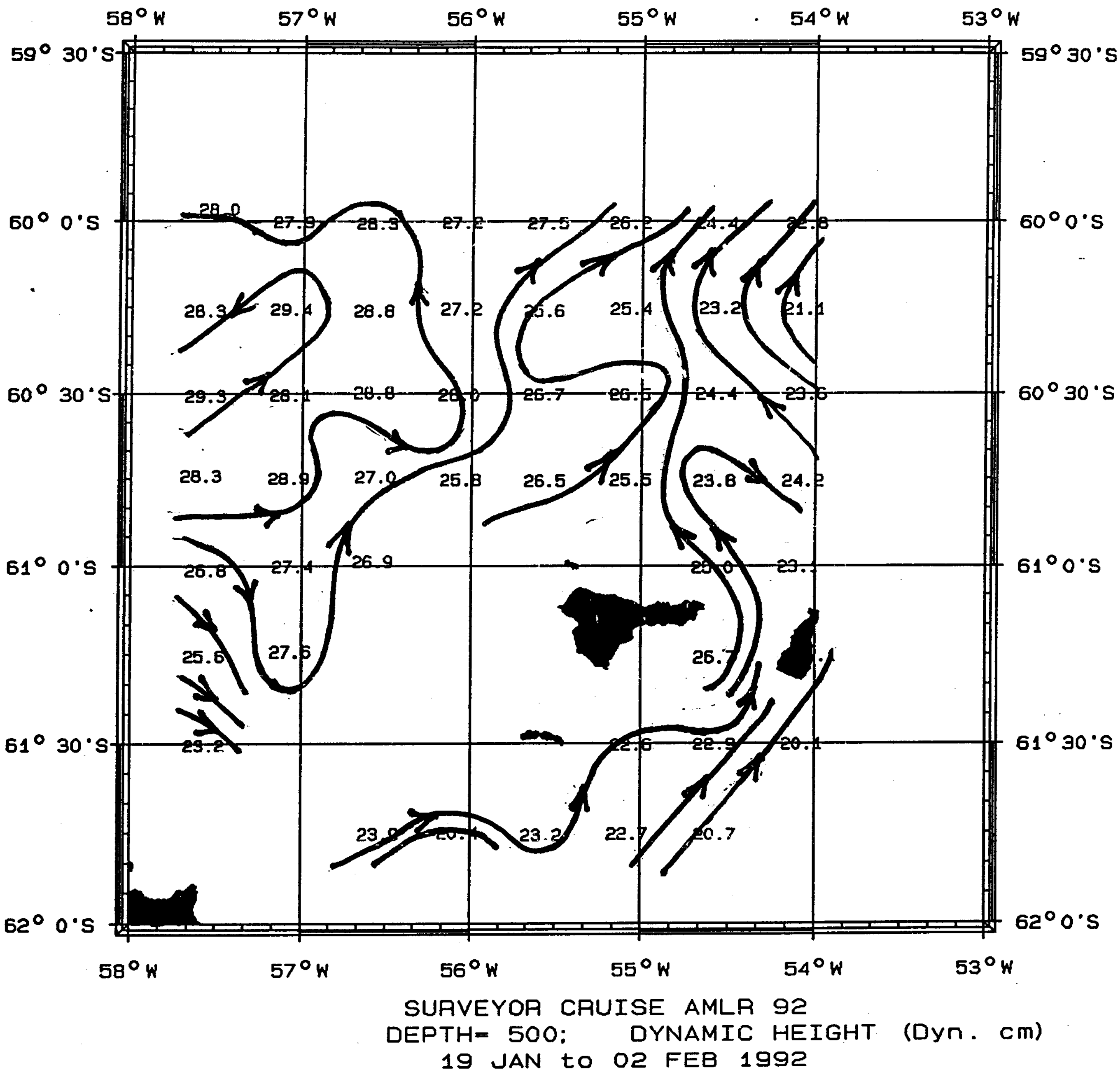

Figure 1.5a Map of dynamic height of the sea-surface relative to the 500 decibar level with streamlines of the geostrophic flow, Leg I.

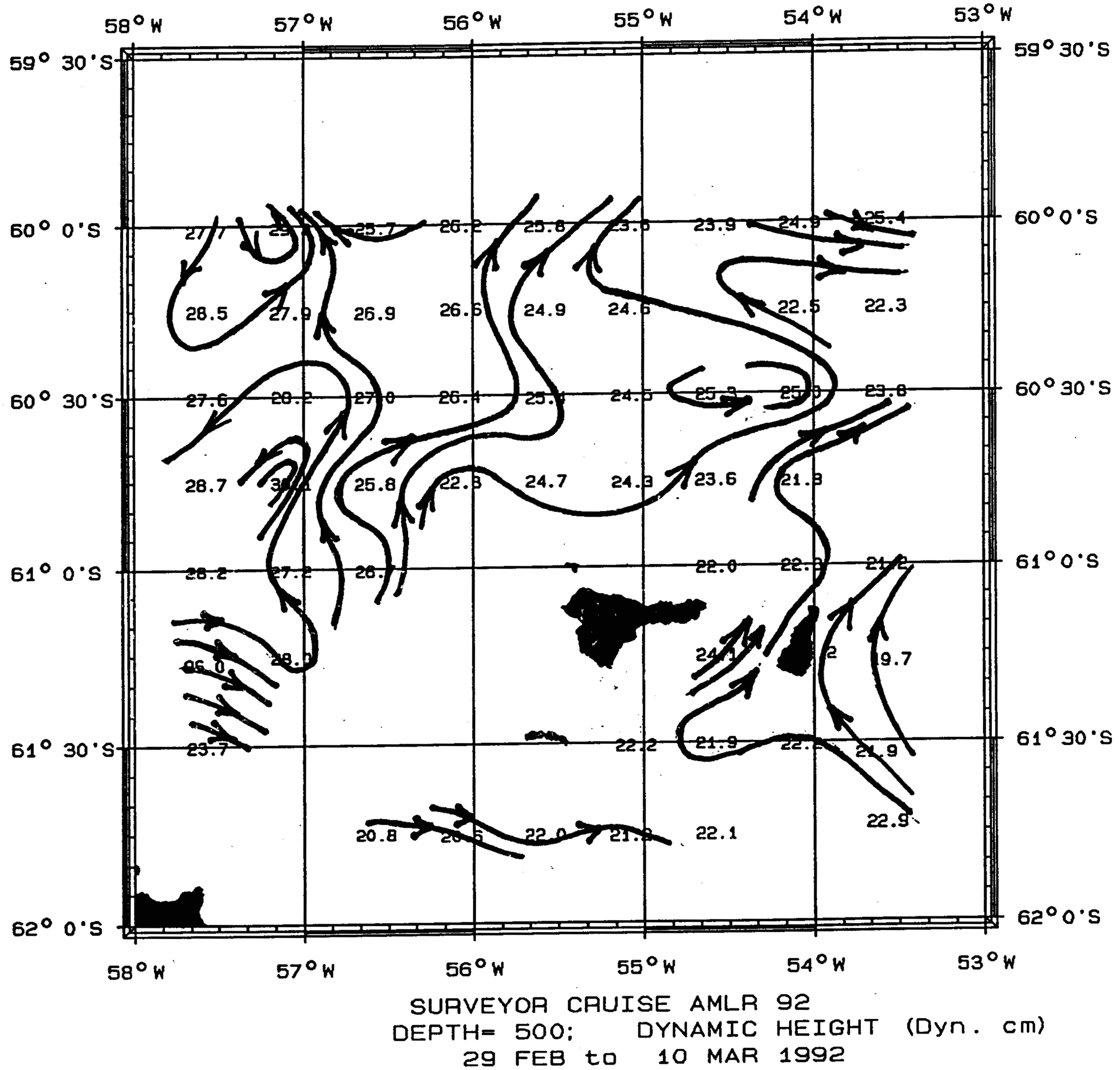

Figure 1.5b Map of dynamic height of the sea-surface relative to the 500 decibar level with streamlines of the geostrophic flow, Leg II.

2. Phytoplankton; submitted by Osmund Holm-Hansen, E. Walter Helbling, Virginia Villafañe, William P. Cochlan, Scripps Institution of Oceanography; Livio Sala, Univ. Nacional de la Patagonia, Argentina; Wanda Garcia, Universidad Católica, Chile; and Christian Bonert Anwandter, Servicio Hidrográfico y Oceanográfico de la Armada.

2.1 Objectives: The overall objectives of our research project were: (1) to document the magnitude and quality of the food reservoir available to grazing zooplankton throughout the AMLR study area; and (2) to improve our understanding of the interrelationships between the physical, chemical, and optical regimes that result in maintaining the food reservoir during the growing season.

Specific objectives included: (a) determination of the food reservoir available to grazing zooplankton including krill; (b) determination of rates of primary production; (c) ecological modelling of primary production rates; and (d) estimation of the relative importance of the factors governing the standing stock of phytoplankton.

Ancillary projects consisted of describing the vertical and horizontal distribution, abundance and productivity of marine heterotrophic bacteria in the study area, and the determination of the biological and physical factors affecting their ecology. We also sought to determine the potential effects of natural ultraviolet radiation (UVR) on phytoplankton and on heterotrophic bacteria activity.

2.2 Accomplishments: The following data were obtained:

(1) Photosynthetic pigments: Chlorophyll-a (chl-a) concentrations were measured in water samples from 11 depths (surface to 750m or shallower), obtained from CTD/rosette casts at 187 stations (64 in Survey A, 72 in Survey D, 44 in Cross-shelf Transects, and 7 in Fine-scale MOCNESS sampling). In addition, 75 samples were frozen (-20°C) for later determination of *in vivo* absorption spectra (280 to 750nm) of the natural phytoplankton communities. In addition, phytoplankton biomass was estimated by *in vivo* chl-a fluorescence measurements of the ship's clean seawater intake (5m) throughout the entire 2-month period.

A pulsed fluorometer was attached to the rosette to measure *in vivo* fluorescence of chl-a from the sea surface to 750m (or as deep as possible at the shallower stations). This fluorometer was working until station D53, when it failed and was subsequently removed from the rosette.

(2) Rate of primary production: At 21 stations, water samples obtained from eight depths (from one of the morning CTD/rosette casts) were incubated to measure rates of primary production under different light levels (from 95 to 0.5 % of surface incident radiance) in incubators cooled with running seawater. Also, special experiments were carried out to estimate the degree of inhibition caused by UV radiation.

In order to have other estimates of primary production for comparison with the classical radiocarbon incorporation technique (in which the samples are kept at a constant percentage of incident solar radiation), we also estimated primary productivity from measurements of upwelling light throughout the water column at 683nm with a hand-deployed instrument (PUV-500) at 37 stations (0 to 80m). We also conducted experiments to measure ^{14}C incorporation by phytoplankton using a rotating incubator which simulates the variable light regime experienced by the phytoplankton within the mixed layer.

(3) **Biomass and organic carbon concentration:** The following samples/measurements were taken/made to determine biomass in terms of carbon content: (a) 84 samples for determination of particulate organic carbon (POC); (b) 168 samples for determination of adenosine triphosphate (ATP); (c) 84 samples for determination of deoxyribonucleic acid (DNA); (d) transmissometer data obtained from the continuous flow system for horizontal distribution and from the rosette array for vertical profiles during all CTD/rosette casts; and (e) 200 samples for determination of phytoplankton cell numbers, sizes and shapes, from which total cellular volumes and organic carbon can be estimated.

(4) **Phytoplankton cell size and species composition:** At every station the following samples were obtained: (a) samples for chl-a determination were filtered-fractionated (Nitex nylon mesh, 20μm pore size) to determine the contribution of the nanoplankton- and microplankton-sized phytoplankton to the total chl-a of the community; and (b) samples for floristic analyses. At every other station a plankton net (20μm) was deployed (horizontal tow, 5 min) to determine net plankton abundance.

(5) **Nutrients:** Water samples for measurement of nitrite, nitrate, phosphate and silicate were taken at all the stations at selected depths (5m, 50m, 200m, & bottom), and frozen (-20°C) for later analysis ashore.

(6) **Light measurements:** The following data on incident solar radiation were collected throughout the study area: (a) continuous monitoring (every minute) of Photosynthetic Available Radiation (PAR), Total UltraViolet Radiation (TUVR), and total light energy from 285 to 2800nm (instruments located on the flying bridge); (b) continuous monitoring (every minute) of PAR and four different channels (308, 320, 340 and 380nm) of UV radiation (instrument on the helopad adjacent to the incubators); (c) vertical depth recording of underwater PAR (sensor mounted on the rosette) for measurement of the attenuation of solar radiation in the water column; (d) hand deployment of a profiling unit to measure PAR, four channels of UVR, temperature and 683nm upwelling light (0 to 80m) when weather conditions permitted; (e) a continuous recording of the total light flux during any incubation period using an integrating PAR sensor (mounted adjacent to the deck incubators); and (f) a direct measure of the light flux to the samples (rate-meter PAR sensor inserted into the incubation tubes).

(7) Krill gut content: At selected stations (Leg I: 9, Leg II: 19) between 10 and 20 krill were extracted with 90 % acetone for measurement of gut content fluorescence. Also, during Leg II, grazing experiments were performed in which krill were allowed to feed on labelled (^{14}C) phytoplankton cultures at two different concentrations (0.4 and 1.9μg chl-a/l).

(8) Bacteria: During Survey D, samples were collected at every other station from 5, 50 and 200m and preserved for enumeration of free and attached bacteria in the water column. Samples for bacteria counts were fixed in borate-buffered formalin (2 % final concentration) and stored at 4°C in the dark until counting by epifluorescence microscopy.

At 10 stations, in conjunction with the primary production experiments, samples were collected throughout the water column (5, 15, 30, 50, 75, 100, 200 and 750m) for both enumeration of bacteria and measurement of heterotrophic activity according to a modification of the tritiated thymidine method. Samples were incubated in the dark for 2 hours at *in situ* temperature. After incubation, samples were filtered through 0.22μm Millipore filters, rinsed five times with 2ml of ice-cold 5 % trichloracetic acid (TCA), and stored for liquid scintillation counting at SIO. Experiments were also conducted to verify the appropriate incubation time and thymidine concentration for these experiments. At selected stations (D12 and X31), samples were preserved with electron microscopy grade glutaraldehyde (2.5 % final concentration) and stored in sterile polypropylene centrifuge tubes in the dark at 4°C for the enumeration of viruses (bacteriophages and phytoplankton viruses) using transmission electron microscopy at SIO.

(9) Impact of UVR: Preliminary bacteria production experiments were conducted on surface samples in concert with the phytoplankton experiments to determine the potential effects of natural levels of ultraviolet radiation on autotrophic and heterotrophic production and their recovery from UVR damage.

2.3 Results and tentative conclusions:

Leg I:

(a) During Survey A, the phytoplankton distribution, as estimated by chlorophyll-a (chl-a) concentration, showed higher integrated values (in mg chl-a/m^2, from 0 to 200m) to the south of a line that runs from southwest to northeast (see heavy line in Figure 2.1, bottom diagram). However, two patches with more than 50mg chl-a/m^2 were observed to the north of this line. Contour plots of the distribution of chl-a in the water column (0 to 200m) for the eight transects done during Survey A (upper 8 diagrams) are shown in Figure 2.1. In general, chl-a concentrations were higher in the southern stations with relatively high values (> 0.3μg/l) down to more than 150m.

(b) Preliminary analyses of net phytoplankton community (> 20μm) revealed the existence of three major zones of different species domination in the study area. The tentative boundaries between these zones are plotted in Figure 2.2. The net phytoplankton in zone I was dominated by chain-forming diatoms (mainly Rhizosolenia sp.), while in zone II net plankton were dominated almost exclusively by Chaetoceros sp. In zone III, however, the dominant phytoplankters were discoid diatoms between 30-40μm in diameter.

(c) A typical profile of the upper 250m of the water column is shown in Figure 2.3. It is possible to observe a shallow mixed layer (ca. 35m); transmissometer, chl-a and *in vivo* fluorescence of chl-a data indicate a high concentration of particles within this mixed layer with decreasing concentrations beneath it. From the comparison of *in vivo* fluorescence and extracted chl-a values (Figure 2.3), a decrease in the fluorescence yield is observed down to ca. 25m.

(d) The mean PAR level for Leg I was 1100μE/m^2/s, and the daily daylight mean was 68 E/m^2/day. Data collected on February 3 for the four channels of UVR and one channel of PAR are shown in Figure 2.4. The underwater light conditions of station A41 for UVR is shown in Figure 2.5. It is possible to observe penetration of UV-B (280-320nm) down to 20m depth and UV-A (320-400nm) down to more than 50m. For the same station, a typical vertical profile for temperature, PAR, 683nm upwelling light (LuChl) and productivity is shown in Figure 2.6.

Leg II:

(a) During Survey D, chl-a concentration was horizontally variable with high values (> 1.4μg chl-a/l) at the northern and southwestern stations of our sampling grid (Figure 2.7). Integrated chl-a (0 to 200m) also followed this pattern (Figure 2.7, lower diagram), although there was a general decrease in chl-a concentration in the area since Leg I. The mean integrated chl-a concentrations for the whole area were 36.4 and 32mg chl-a/m^2 for Surveys A and D, respectively. As observed during Leg I, the phytoplankton community was mainly dominated by the nanoplankton fraction (< 20μm), and they accounted for 60 to 95 % of the total chl-a concentration in the water column.

(b) During Leg II, there were generally cloudy conditions and the mean PAR level for this leg was 800μE/m^2/s; the daily daylight mean was 40E/m^2/day. Data collected on March 5 for four channels of UVR and one channel of PAR are shown in Figure 2.8 (note the decrease in all light channels when compared with Figure 2.4).

2.4 Disposition of data and samples: Nutrient analyses will be carried out with an autoanalyzer at the Universidad Católica de Valparaiso, Chile. All the other samples (except those analyzed on board) will be returned to SIO for final processing. The entire data set, when completed, will be available to NOAA and to all AMLR investigators either in hard copy or on computer disk. Contact persons: Dr. Osmund Holm-Hansen or Mr. Walter Helbling, Polar Research Program, Scripps Inst. of Oceanography, UCSD, La Jolla, California, 92093-0202. FAX: (619) 534-7313, Phone: (619) 534-8525, e.mail (omnet): O.Holm.Hansen

2.5 Acknowledgements: We wish to thank the Antarctic Marine Living Resources (AMLR) program, and the officers and crew of the NOAA Ship *Surveyor* for excellent support. We also want to thank the Physical Oceanography project for data collection and the Krill Sampling project for providing krill for our experiments.

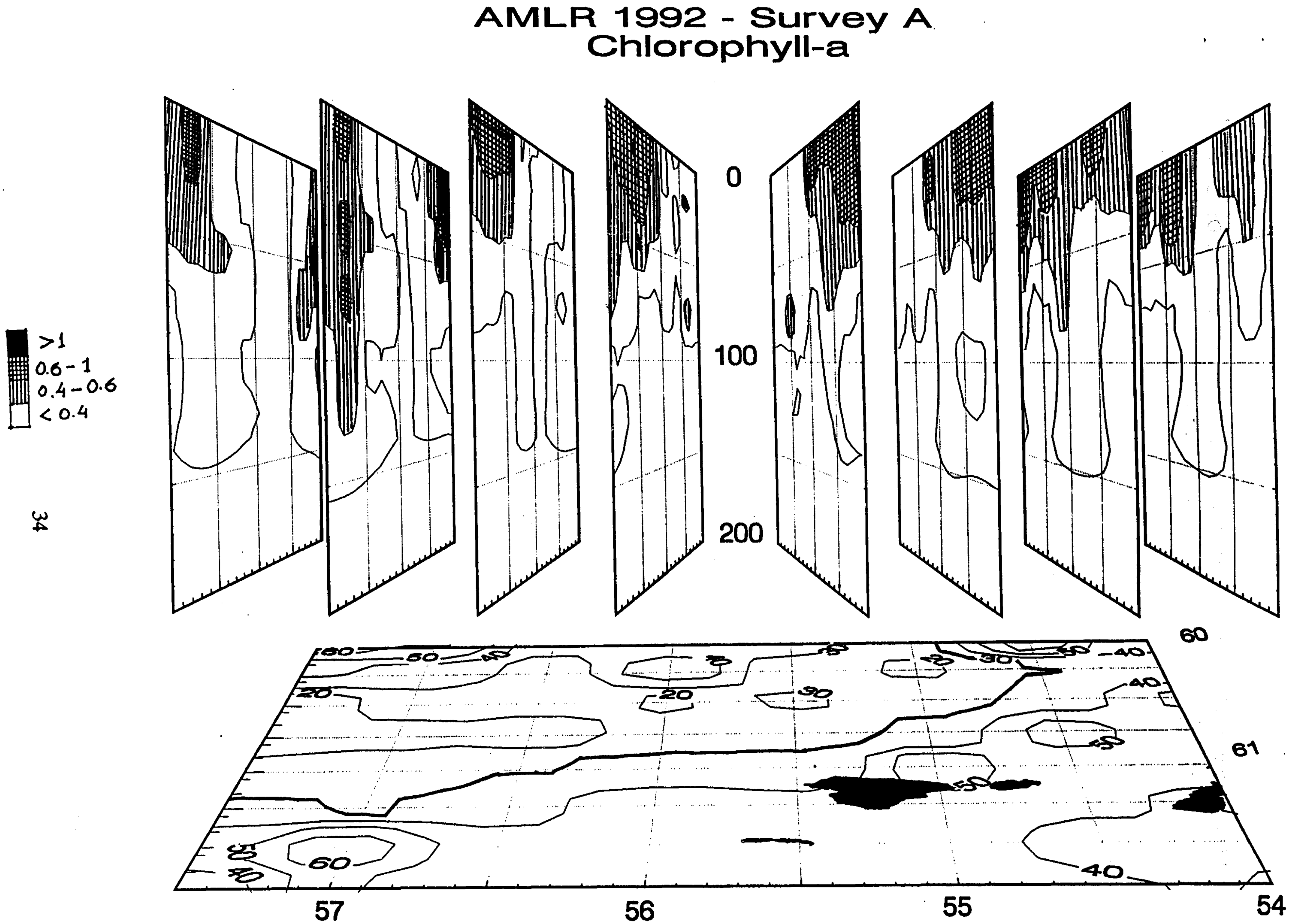

Figure 2.1 Chlorophyll-a distribution, Survey A.

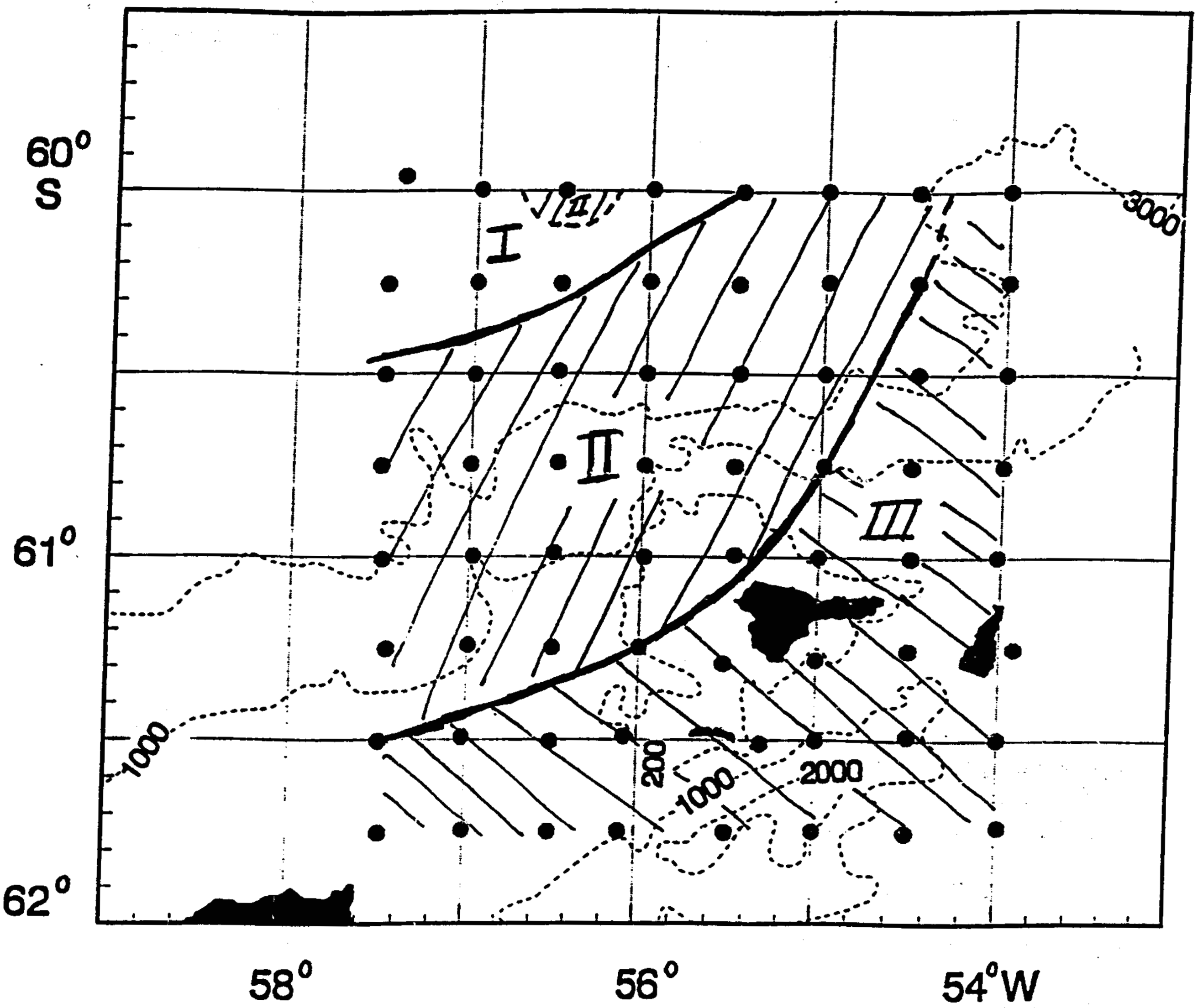

Figure 2.2 Boundaries between major zones of different species of phytoplankton.

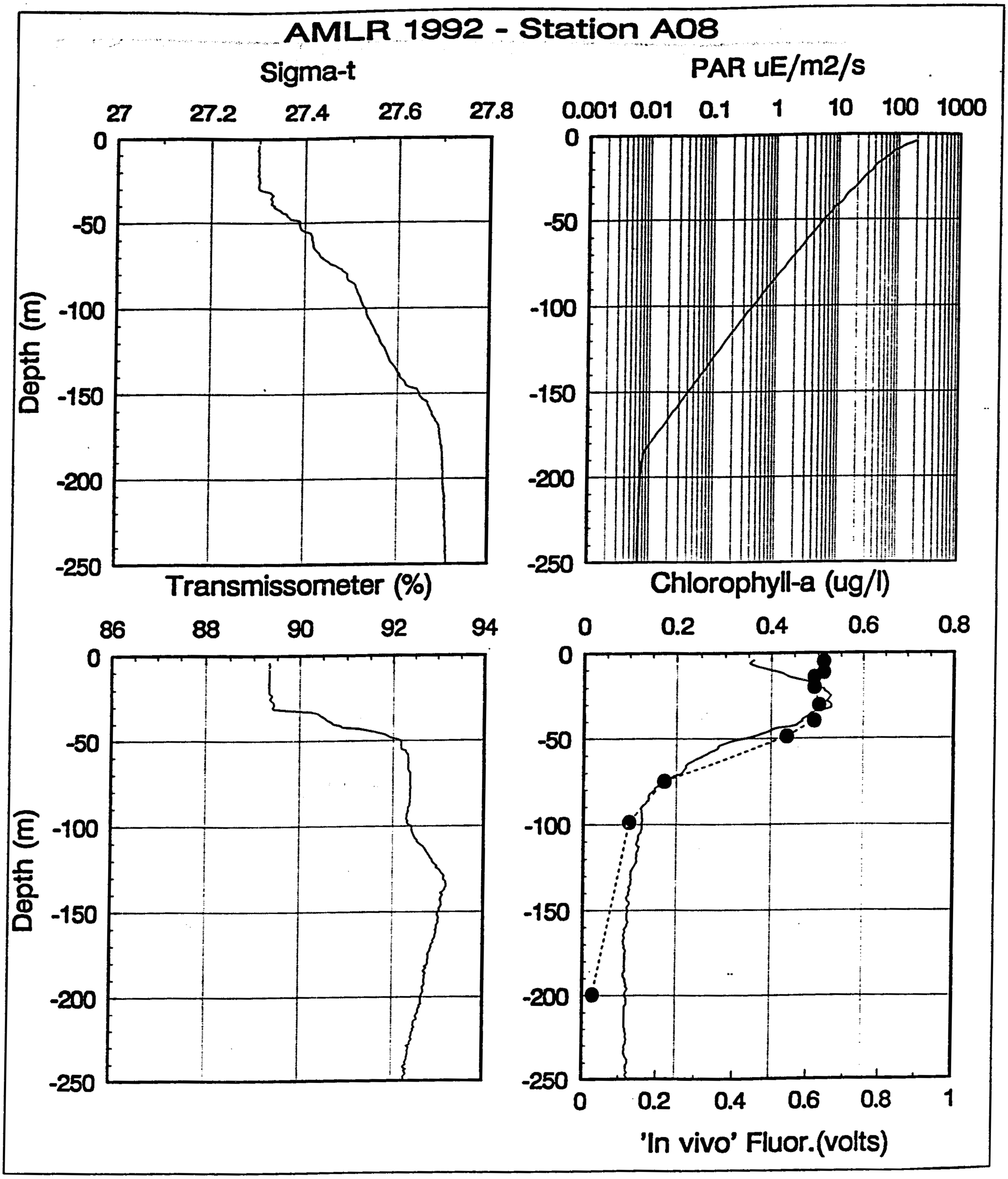

Figure 2.3 A typical profile of the upper 250m of the water column.

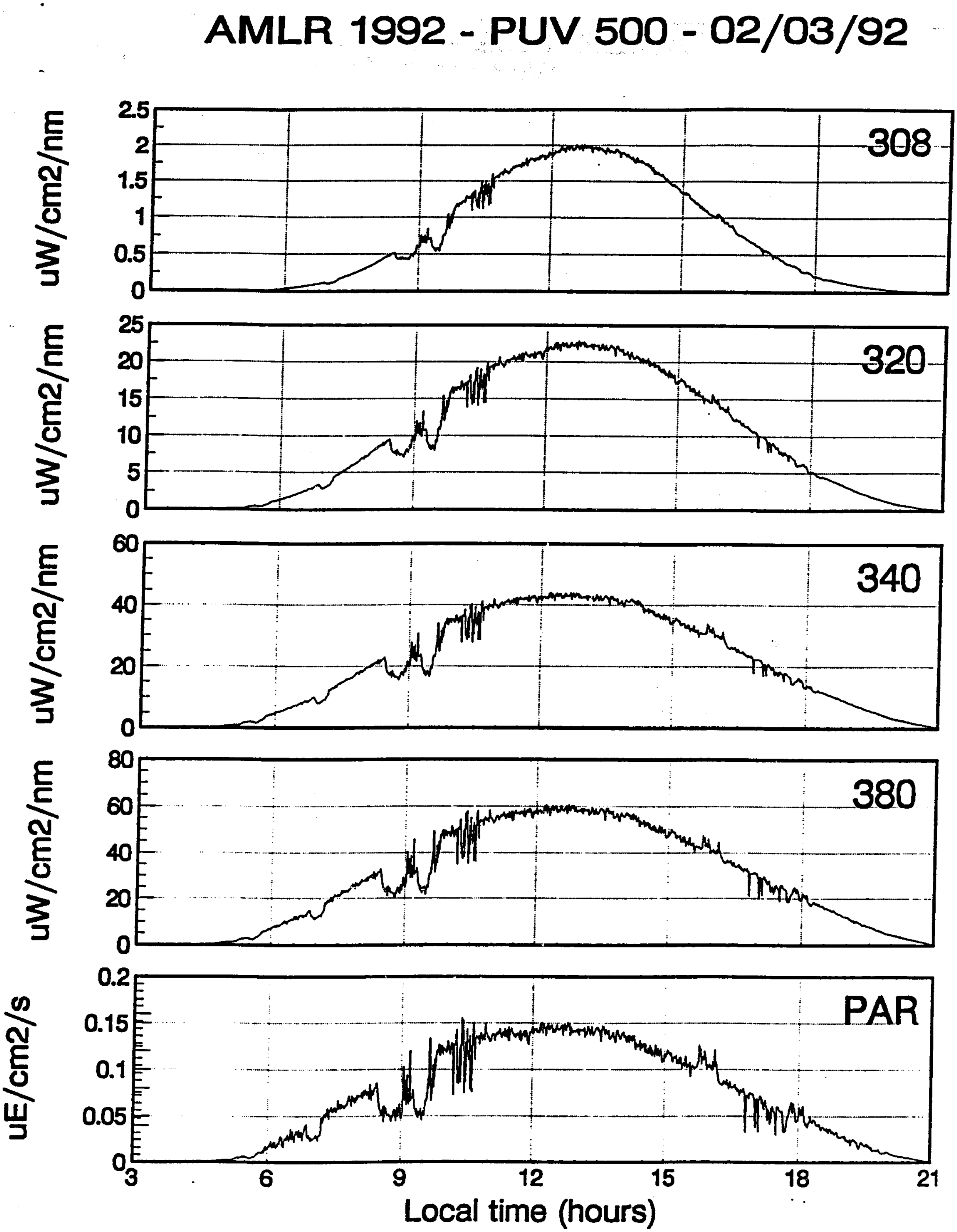

Figure 2.4 Data collected on February 3 for the four UVR channels and one PAR channel.

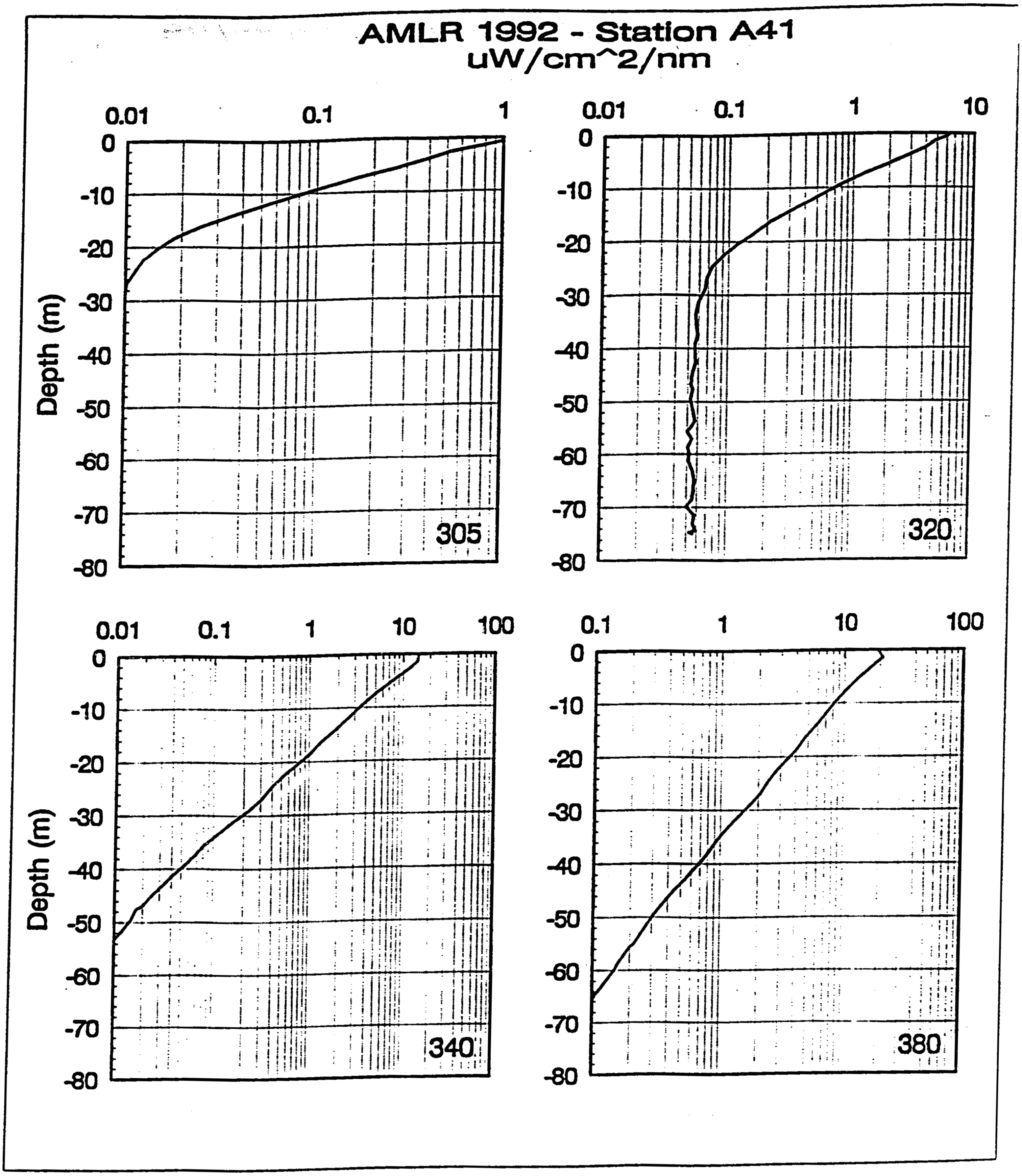

Figure 2.5 Underwater light conditions of Station A41 for UVR.

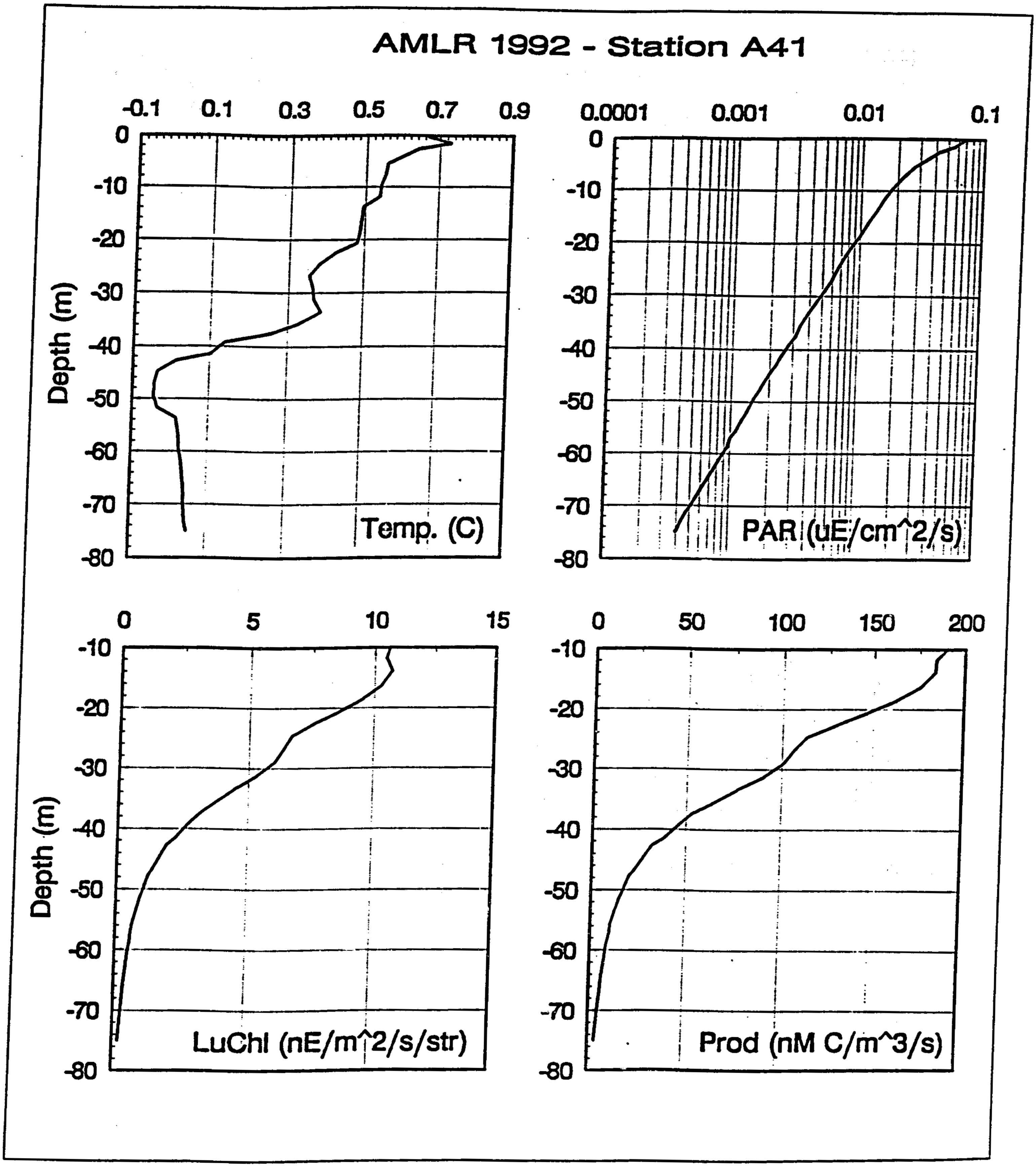

Figure 2.6 Typical vertical temperature profile, PAR, 683nm upwelling light (LuChl), and productivity for Station A41.

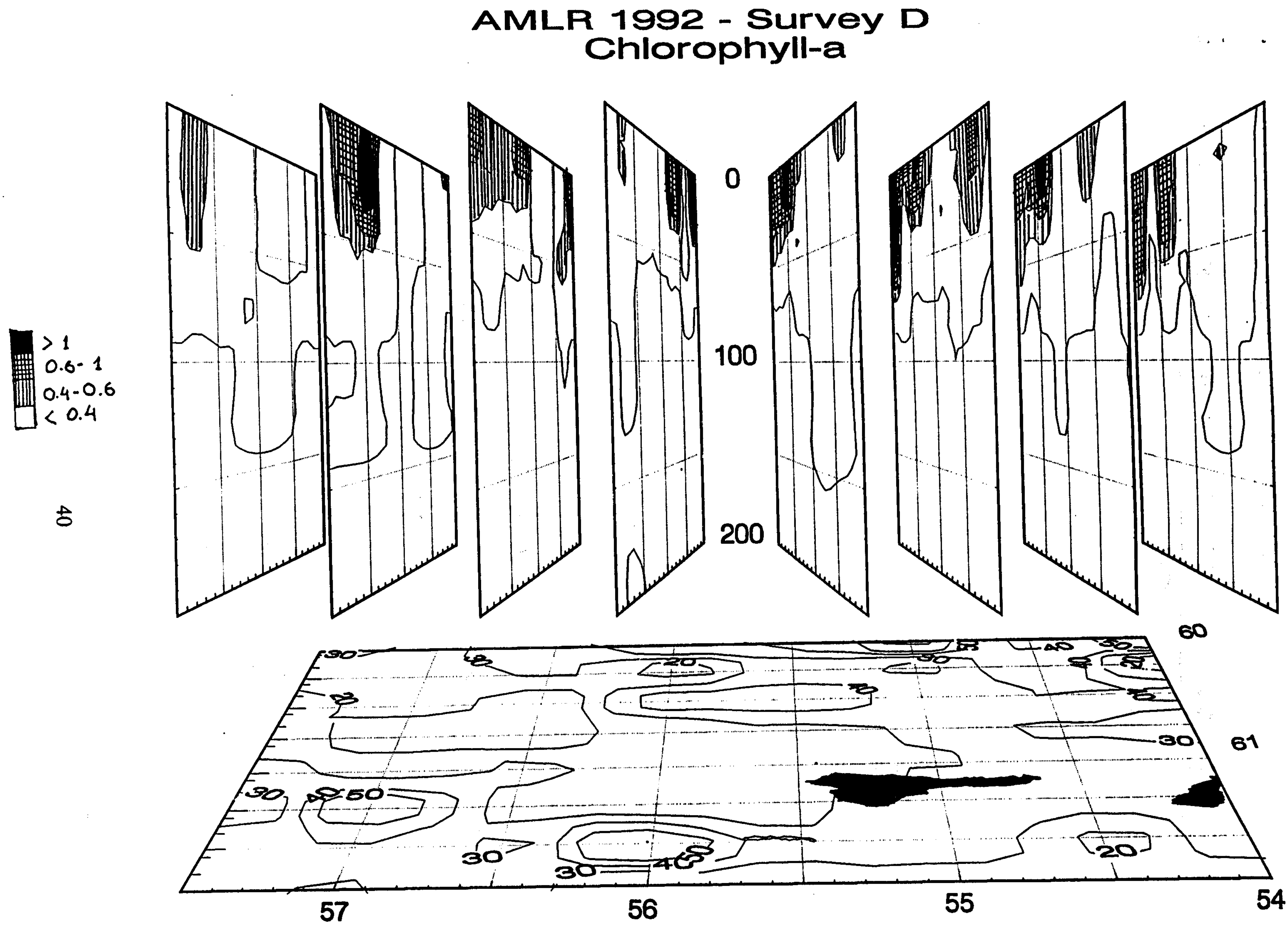

Figure 2.7 Chlorophyll-a distribution, Survey D.

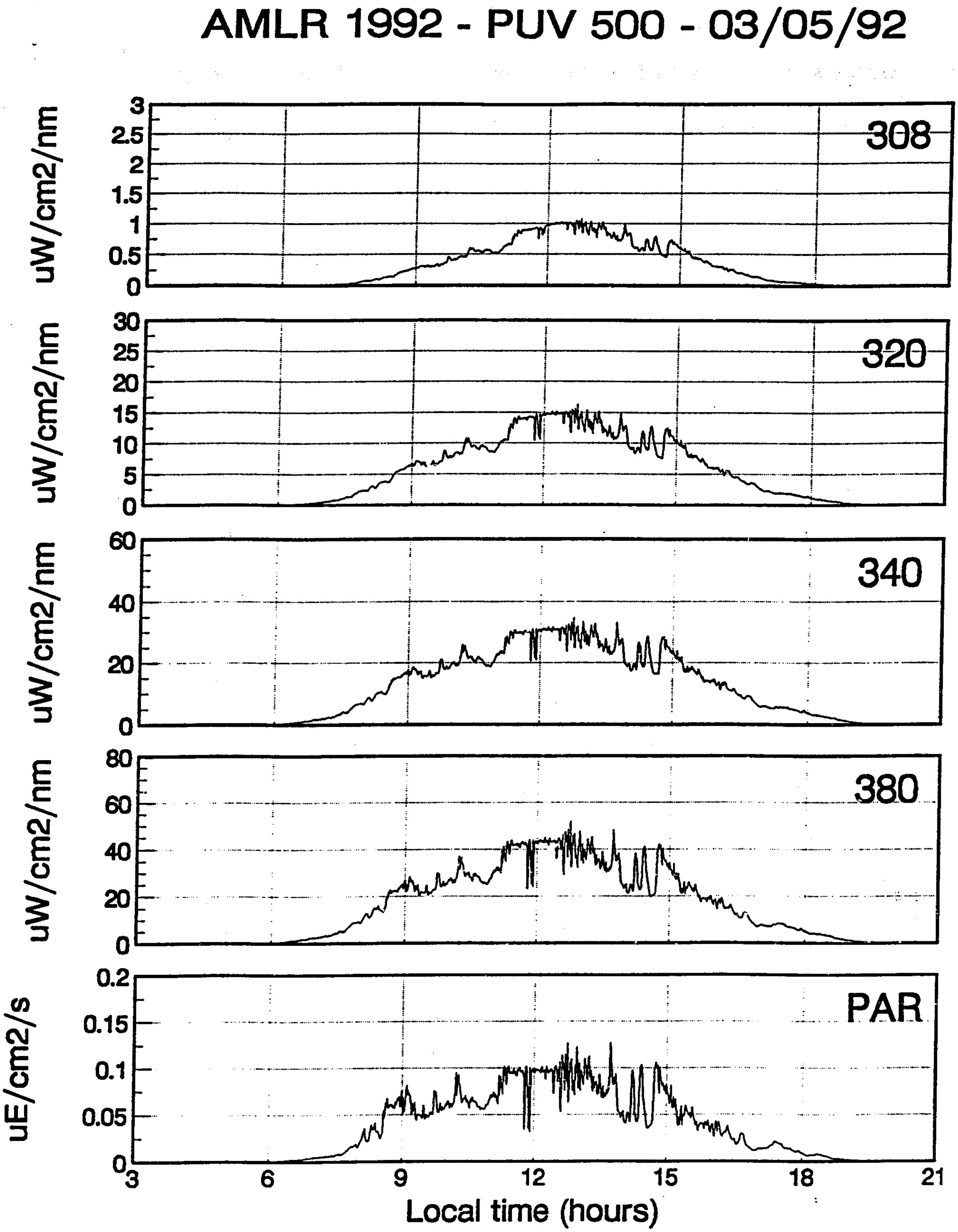

Figure 2.8 Data collected on March 5 for the four UVR channels and one PAR channel.

3. Hydroacoustic survey; submitted by David Demer, Duncan McGehee, Scripps Institution of Oceanography; Roger Hewitt, Jane Rosenberg, and Stephanie Sexton, Southwest Fisheries Science Center.

3.1 Objectives: The predators of krill have vital requirements for both the quantity and location of their prey. Consequently, the primary objectives of the hydroacoustic survey were to map krill (*Euphausia superba*) in the vicinity of Elephant and Seal Islands and to estimate their biomass, both at the height of austral summer and in the early fall. Secondary goals included the acquisition of data that may better define krill target strengths, diurnal migration patterns, swarm sizes, and inter-swarm spacings. Ancillary studies addressed the differentiation of species in the survey area via acoustic signatures.

3.2 Accomplishments: An echo-integration system was used to map and quantify krill over five spatial scales: (1) large-area surveys (Surveys A and D), (2) small-area surveys (Surveys B and C), (3) cross-shelf transects (X stations), (4) fine-scale MOCNESS sampling (M stations), and (5) fine-scale acoustic survey. Additionally, an acoustic transect was made across the Drake Passage. The acoustic system was operated during a total of 5000 n.mi. of trackline.

The main components of the acoustic system included a Simrad EK500 Scientific Echosounder (including a color monitor and printer), a UNIX workstation with BI500 postprocessing software, the ship's MX200 GPS receiver, an ETHERNET communication link, and a dead-weight towed body. The EK500 is an echo integration system equipped with a 160 dB dynamic range capable of detecting single euphausiids or large swarms, without a threshold adjustment. To collect target strength data of individual organisms, the echosounder was equipped with a single 120kHz split-beam transducer. The beam pattern was narrow, with 9.0 degrees between half-power points. A 1kW pulse of 1.0ms in length was transmitted once per second. The pulse was shortened to 0.1ms during most net tows to optimize for target strength detections. GPS fixes were logged every 10 seconds when available. The dead-weight towed body, housing the transducer, was towed 5-10m below the surface at speeds between 2 and 12 knots. The insonified volume of interest was roughly conical, extending to a depth of 250m from the surface and to a maximum horizontal range of 19.6m, totalling approximately 100,724m^3. A Sun SparcStation 1+ was used for postprocessing, data archiving, and review of echograms. Postprocessing included echo-integration, target strength analyses, and contour mapping. The high volume acoustic data were stored in both raw and processed form on two 1-gigabyte (GB) hard disks and subsequently archived on 1.3GB digital audio tape (DAT).

Leg I:

Survey A: The large-area survey covered an area of roughly 11,025 n.mi.^{2}, centered about 20 n.mi. to the northwest of Elephant Island (Figure 2--Introduction). It was comprised of eight north-south transect lines, each nominally 105 n.mi. long, with 15 n.mi. east-west separation. There were eight stations, spaced 15 n.mi. apart, along each transect. The entire survey took 17 days to complete at 8 knots and covered approximately 1000 n.mi. At each station, the acoustic survey was temporarily halted for the CTD/rosette cast. However, the acoustics were deployed during all net tows, with parameters optimized for target strength measurements. Volume backscattering strength was integrated over 7 to 250m in depth and averaged over 1.0 n.mi. distances. A contour plot (Figure 3.1) was created from the echo-integration data which were interpolated over the entire survey area. Although a contour plot of this type cannot define true small-scale features of krill distributions, it is valuable in defining the gross features of background krill concentrations.

Cross-shelf Transects: Two cross-shelf transects were conducted from the shoal of Elephant Island to the northeast and to the northwest (Figure 3--Introduction). Transect 1 (NE-SW, X01-X08) covered about 35 n.mi., and transect 2 (SE-NW, X09-X16) covered approximately 40 n.mi. Together, the transects took about 2 days to complete. The acoustic system was deployed between each station at 5 knots, and during IKMT deployments at 2 knots. The system was temporarily stopped during CTD/rosette casts.

Survey B: The small-area survey covered an area of approximately 1,925 n.mi.^{2}, centered about 20 n.mi. due north of Elephant Island (Figure 4--Introduction). It involved 12 north-south transect lines, each approximately 35 n.mi. long, with 5 n.mi. east-west separation. There were three XBTs launched during each transect at the beginning, middle, and end. The survey took two days to complete at 10 knots and covered about 750 n.mi. The integrated volume backscattering strength was interpolated over the entire survey area and plotted topographically (Figure 3.2).

Fine-scale MOCNESS Sampling: The acoustic system was used to direct MOCNESS sampling in four high biomass areas to the north and northwest of Elephant Island (a,b,c,d in Figure 5--Introduction). The areas were identified as having large krill concentrations from the contour plots of Surveys A and B (Figures 3.1 and 3.2). Upon reaching the zone of interest, the acoustic system was monitored in conjunction with the MOCNESS deployment. Through this method, vertical and horizontal distributions of species and inter-species demographics were identified. By matching this data with acoustic signatures, the net sample data provided insight into the various acoustic returns received from different organisms. Thus, the directed MOCNESS results might be extrapolated to other acoustically surveyed areas in the region. Furthermore, acoustic target strength (TS) measurements of krill were collected during the net tows, providing TS versus length correlations. As a consequence, TS models may be further refined.

Leg II:

Survey C: The small-area survey repeated Survey B; a contour plot was created (Figure 3.3). The purpose of repeating the survey was to examine the time varying nature of krill distribution on a temporal scale of one month, as the southern hemisphere moved from summer into fall.

Survey D: The large-area survey repeated Survey A; a contour plot was created (Figure 3.4). Again, the purpose of repeating the survey was to study the time varying nature of krill distribution.

Cross-shelf Transects: Four cross-shelf transects were made in the shelf area north of Elephant Island. Transect 3 (N-S, X17-X21) covered about 20 n.mi.; transect 4 (W-E, X22-X28) covered about 15 n.mi.; transect 5 (NW-SE, X29-X36) covered roughly 40 n.mi. and duplicated transect 2 from Leg I. However, it was run in the reverse direction. Transect 6 (SW-NE, X37-X44) covered about 35 n.mi. and duplicated transect 1 from Leg I. The acoustic system was deployed between each station at 8 knots and during IKMT deployments at 2 knots. The system was temporarily stopped during CTD/rosette casts. Heavy seas forced us to stop deploying the towed body after station X20 in transect 3.

Fine-scale Acoustic Survey: The fine-scale acoustic survey was an intensive 44-hour study of a square nautical mile centered at 61°03.60'S, 56°00.50'W. This location, west of Elephant Island, was identified as having high krill abundance from the density map developed in Survey D (Figure 3.4). The square was divided into 21 north-south tracklines (with approximately 100 meter spacing), and 21 east-west tracklines, which the ship followed at an average speed of 8 knots. Three north-south grids and 4 east-west grids were completed. The purpose of this study was to acquire data defining the three-dimensional structure of krill aggregations. The results from this survey require extensive processing and will not be presented here.

3.3 Tentative conclusions: Krill distribution is highly variable, both in time and space. Figures 3.1 through 3.4 depict the results from Surveys A through D in chronological order. The horizontal distribution of acoustic scatterers, presumed to be mostly krill (but also possibly salps and fish), is presented in terms of integrated volume backscattering, where the units are m^2 of scatterers/$n.mi.^2$. Figure 3.1, showing the results from Survey A, indicates that the highest density of scatterers is found in a band north of Elephant Island and wrapping around it to the west. Figure 3.2 also indicates that the shallow waters north of the island are very productive in terms of krill. However, three weeks later, the same area was studied in Survey C (Figure 3.3); the abundance of scatterers had decreased in some of the shelf waters, although not in the area near Seal Island. Finally, Figure 3.4 shows the results from the large-area Survey D, 6 weeks after Survey A. The abundance of acoustic scatterers has plummeted, leaving only a few pockets of high abundance west of Elephant Island.

Figures 3.5 through 3.8 are examples of acoustic backscattering strength echograms produced by the Simrad EK500 echosounder. High density regions of acoustic scatterers were frequently found on the shelf or the shelf break (Figure 3.5). It should be noted, however, that most of the shoals in the survey area were to the north of Elephant Island, where a protective lee may be the primary consideration. These observations should be studied further.

Diurnal migration was clearly evident, with the biomass residing deeper in the water-column during light hours and rising to the surface, or closer to it, in the twilight and night. This phenomenon can be seen in Figure 3.6 where, at close to midnight GMT (21:00 local time), the scattering layer moves from about 40m deep to near the surface in about 15 minutes.

Throughout the survey, three main types of swarm formation were evident. Diffuse cloud-like aggregations were the most common, lengthy in horizontal dimension and forming one or more thin and distinct layers (Figure 3.6). Other times, discrete dense swarms were common with greater vertical dimensions than horizontal (Figure 3.7). Rarely did these two formation types occur simultaneously. Finally, there were surface swarms, typically at night (Figure 3.8).

3.4 Disposition of data: Integrated volume backscattering data will be made available to other investigators in MS-DOS or UNIX (Sun-OS) format ASCII files. The analyzed echo-integration data, averaged over 1 n.mi. intervals, consume approximately 4MB. The raw data from the acoustic survey totals approximately 50GB in binary form and is currently archived on digital audio tapes. All data are available from David Demer, Southwest Fisheries Science Center, 8604 La Jolla Shores Dr., La Jolla, CA 92037.

3.5 Problems and Suggestions: During net tows, and other times when the ship speed was reduced to below 4 knots, the towed body was prone to pitching. This action was clearly evident in the bottom signal as it modulated up and down by 5-10m in depth. In severe cases, the entire echogram became striped. This is the first field season for this towed body. Consequently, more experimentation with the tail-fin position may lead to greater control over stability at lower speeds.

Since its only depressive force is gravity, the dead-weight body tows with a large catenary in the cable. Consequently, a linear approximation of towing depth from the wire angle and cable paid out is inaccurate. Although the towed body depth was nominally between 5 and 10m, its exact depth versus ship speed and cable length remains unknown. To calibrate the towed body depth versus speed and cable length, the system could be operated in a shallow area with a smooth bottom (<250m). The bottom depth from the EK500 could be compared with the ship's calibrated fathometer at various speeds. However, as winch position and tow-point change from ship to ship, the calibration must be repeated for each vessel. Lack of tenacious cable markings or a metered-block are other drawbacks to this method. Better alternatives are an upward-looking pinger, or a time-depth recorder permanently mounted on the towed body. A radical change, but a common solution, is a hull mounted transducer.

As the *Surveyor* is not equipped with a speed log, the speed-log pulses were generated internal to the EK500 from hand entered, estimated values. Future surveys should incorporate continuously updating speed information, calculated from the GPS fixes. This is not an accuracy concern for the contour plots because GPS fixes were used.

Although the biomass in this area is predominantly krill, acoustic distinction of species is important to make accurate biomass estimates. Also important is an assessment of biomass above 10m and below 250m. The addition of a higher frequency (ie 200kHz), to the acoustic system would greatly enhance the remote species identification effort. An upward-looking sonar would provide very important information about krill biomass in the upper 10m. And, a low frequency capability (ie 38kHz) would extend our understanding of biomass down to about 1km.

Krill swarms have a much finer spatial variability than the distance between feasible acoustic survey tracklines. Consequently, topographic maps created from distantly-spaced volume backscatter strength data will reflect only gross distributional characteristics. Therefore, to enhance the accuracy of the biomass estimates calculated from the interpolated data, and our understanding of fine scale distributional patterns, more coverage of the survey area is required. One mean of accomplishing this goal is with the addition of sideways-looking transducers. Two sideways-looking transducers, coupled with a down- and a up-looking transducer, would more than triple the surveyed volume while covering the same trackline distance.

An accurate distribution of krill target strengths is a critical link in the conversion of integrated volume backscattering strength to biomass. This distribution is highly dependent on krill length and orientation. Length data have been collected via net trawls, but an adequate understanding of krill orientational behavior is missing. By coupling *in situ* target strength measurements with simultaneous underwater photography, great gains could be made towards describing this distribution. A remotely operated vehicle (ROV) fitted with a stereo still camera or video camera would be an optimal platform for such a study.

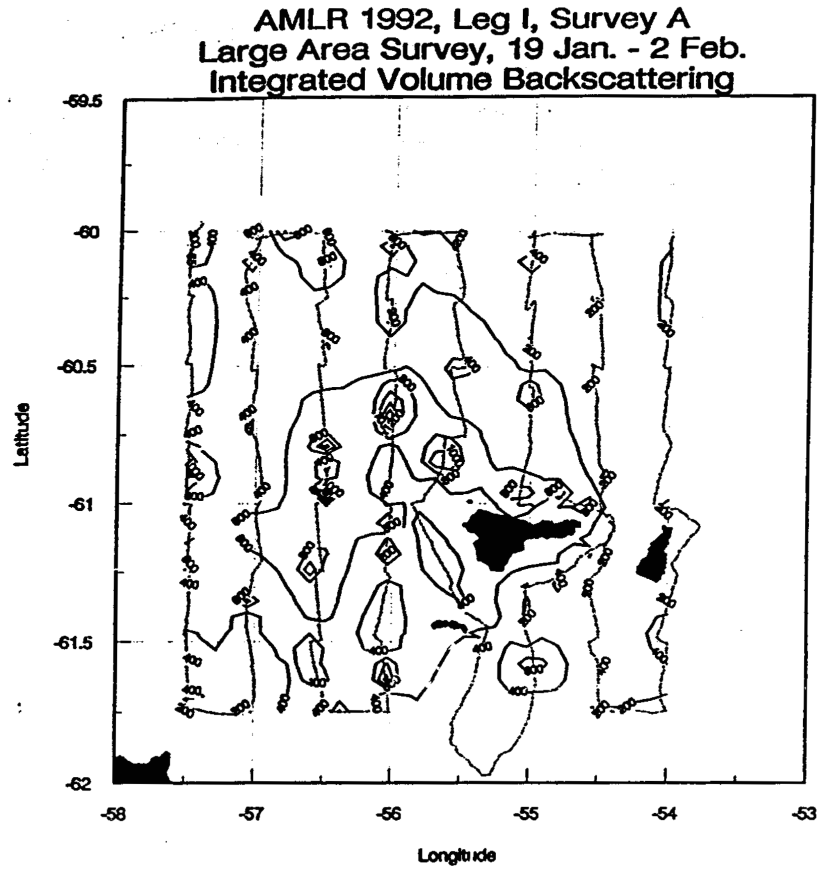

Figure 3.1

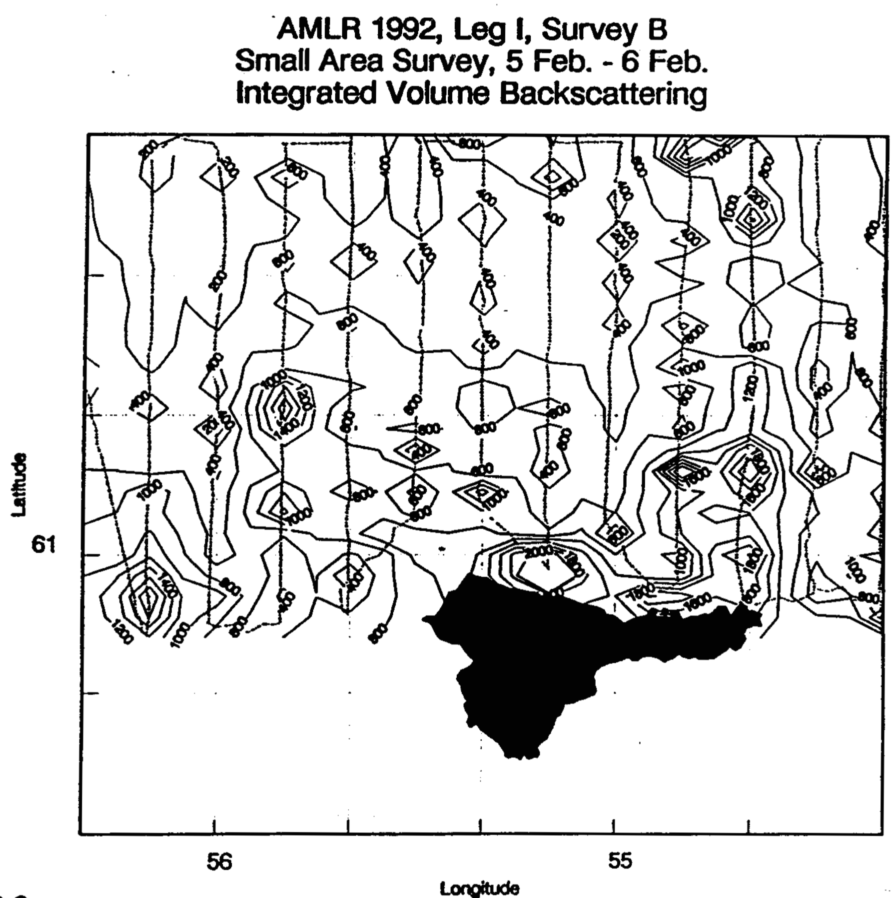

Figure 3.2

AMLR 1992, Leg II, Survey C
Small Area Survey, 25 Feb. - 28 Feb.
Integrated Volume Backscattering

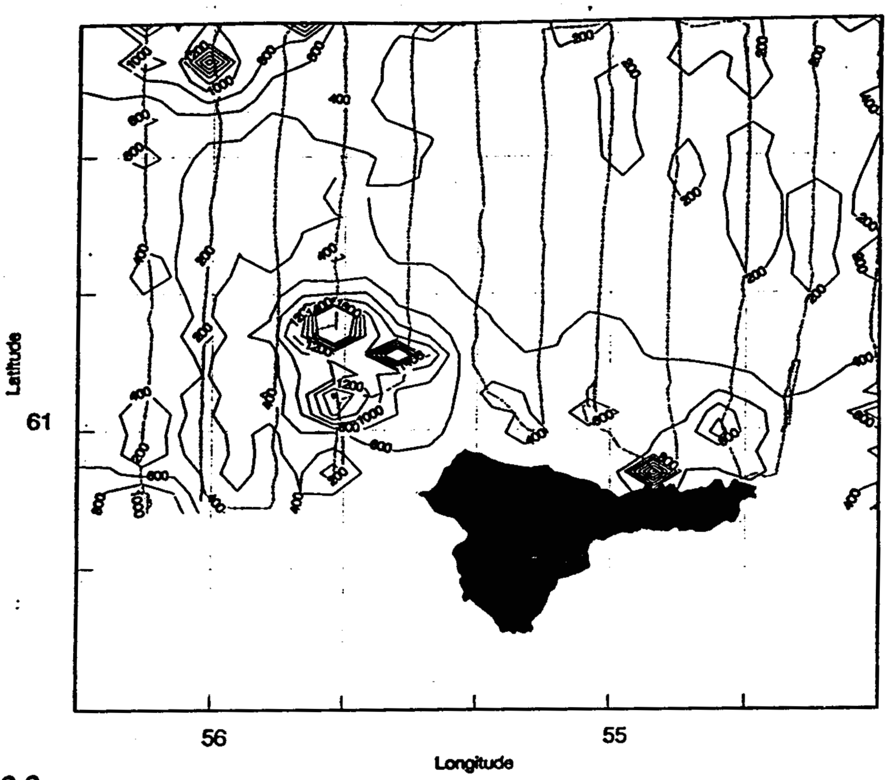

Figure 3.3

AMLR 1992, Leg II, Survey D
Large Area Survey, 29 Feb. - 10 Mar.
Integrated Volume Backscattering

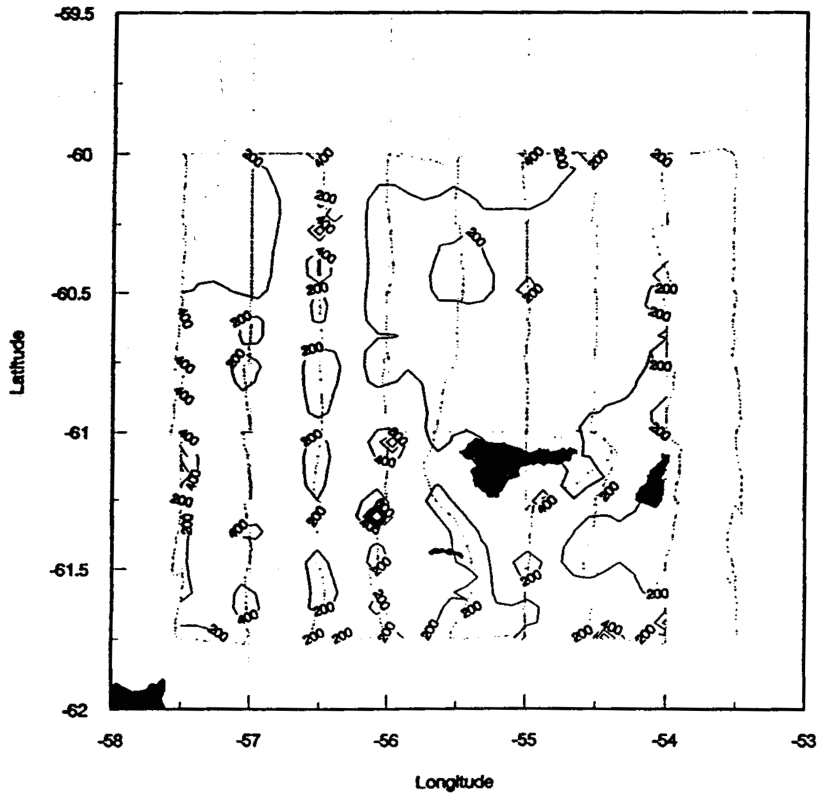

Figure 3.4

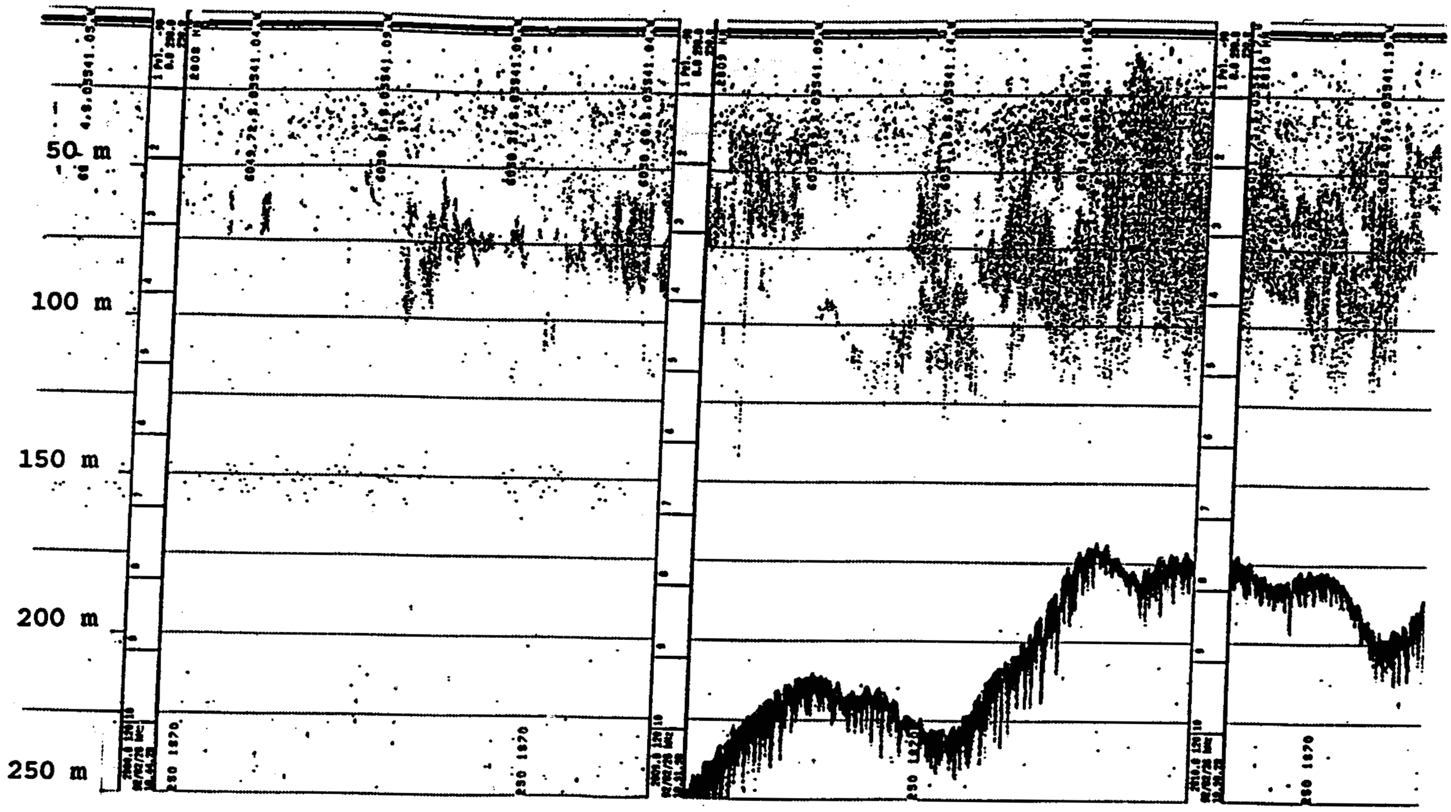

Figure 3.5 Acoustic record from Survey C. Large numbers of acoustic scatterers are often associated with shelf waters.

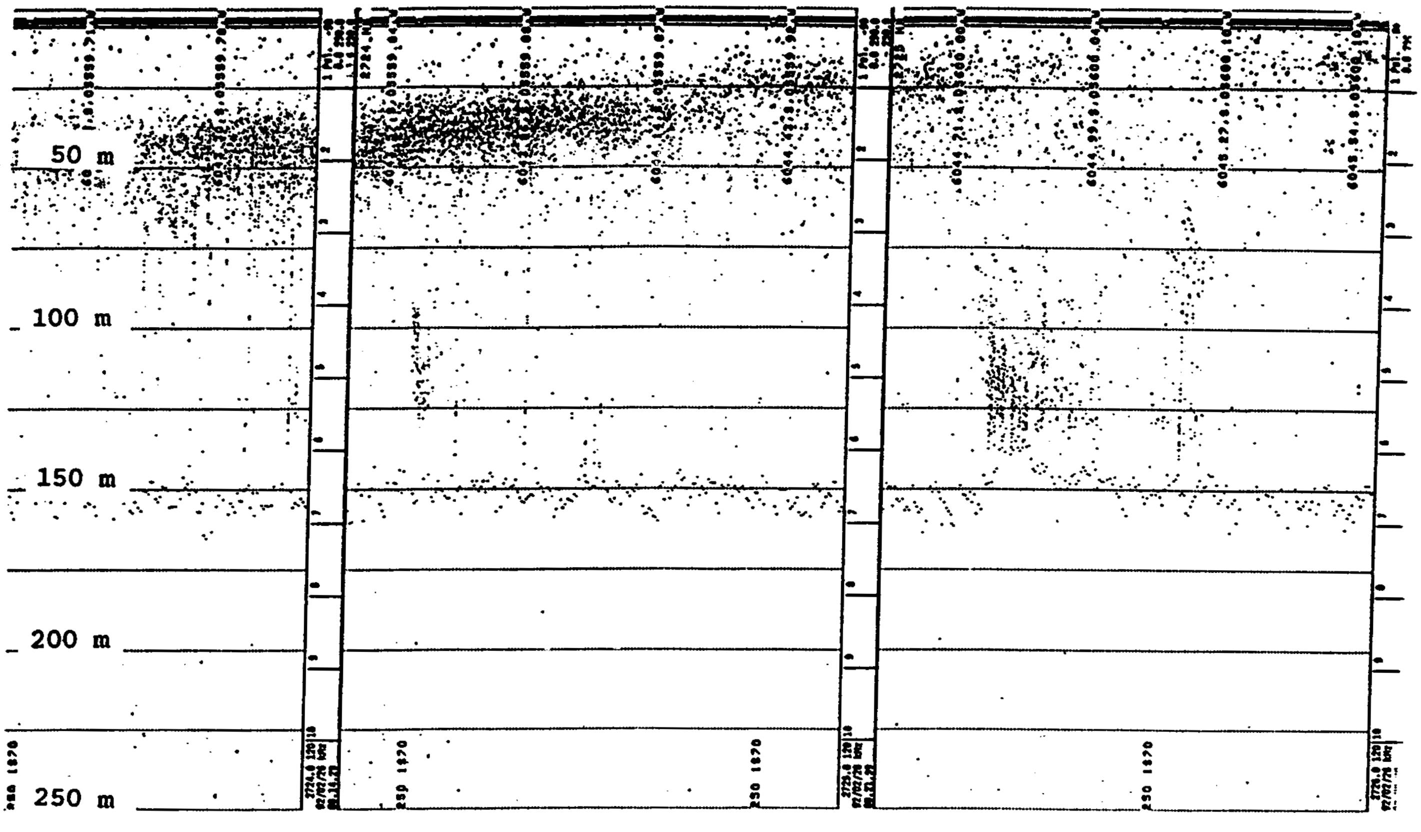

Figure 3.6 Acoustic record from Survey C at 21:00 local time. The diel migration is evident. In approximately 15 minutes the layer of acoustic scatterers moves from about 40 m deep to the surface. The figure also depicts one of the three prevalent swarm types: the diffuse cloud-like swarm, large in horizontal extent but thin in the vertical dimension.

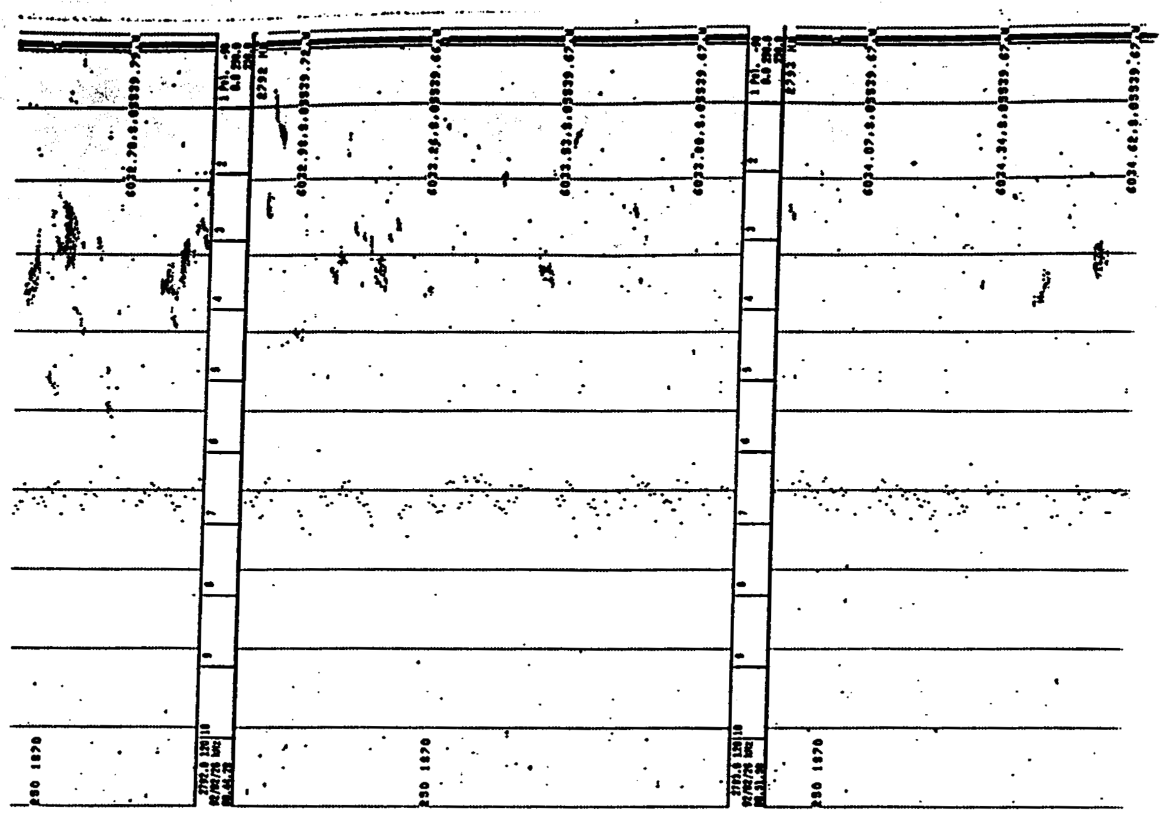

Figure 3.7 Acoustic record from Survey C. The second of the three prevalent swarm types: dense swarms, greater in vertical extent than in horizontal extent.

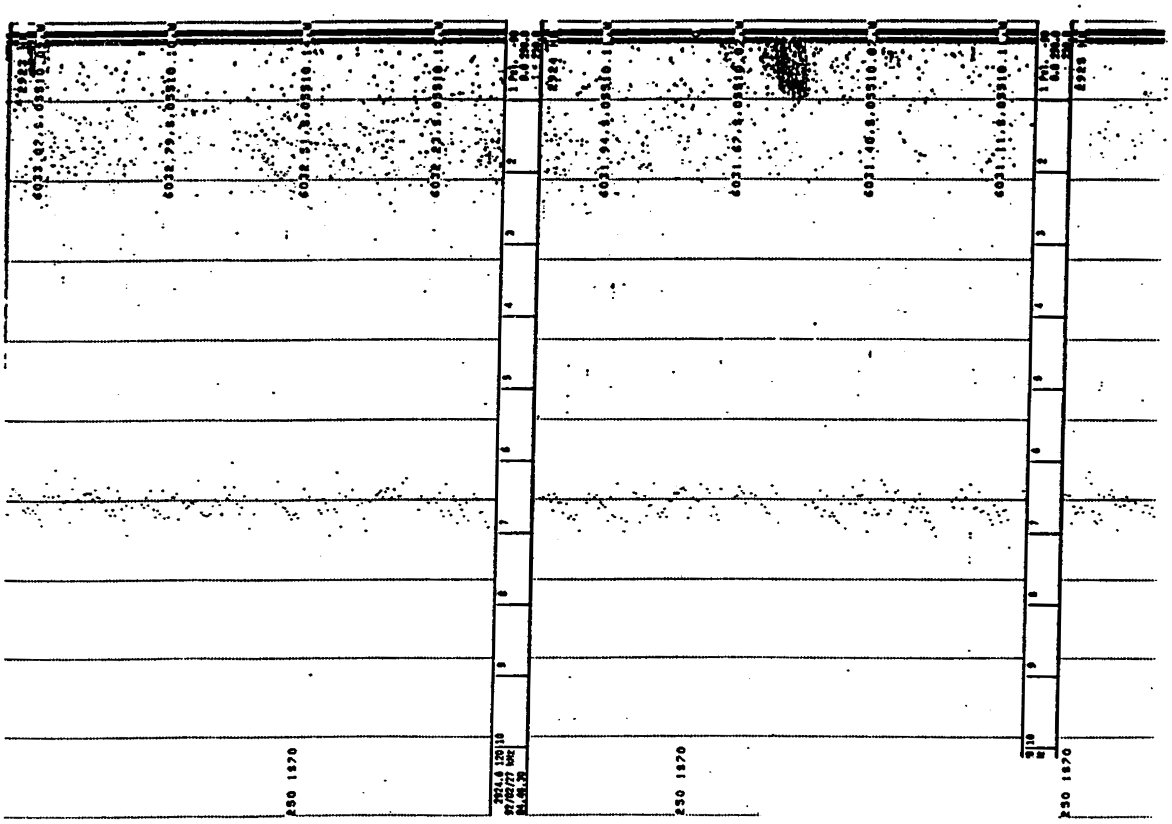

Figure 3.8 Acoustic record from Survey C. The third of the three prevalent swarm types: the surface swarm.

4. Direct krill and zooplankton sampling, Legs I and II (IKMT); submitted by Valerie Loeb, Karen Davis, Frank Roddy, Moss Landing Marine Laboratories; Volker Siegel, Sea Fisheries Research Institute; and Dennis Kelly, Orange Coast College.

4.1 Objectives: The objective of this work was to provide information on the demographic structure of krill and the distribution of larger sized zooplankton components in the Elephant Island study area. Essential demographic information for krill includes length, sex ratio, reproductive condition and maturity stages. Information useful for determining the relationship between krill distribution and population structure and ambient environmental conditions was derived from net samples taken at fixed stations within the large-area surveys and cross-shelf transects. Ancillary information on the abundance and distribution of other larger sized zooplankton components was obtained from the large-area survey samples.

4.2 Accomplishments: Krill and zooplankton were obtained from a 6' Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505μm mesh plankton net. Flow volumes were measured using a calibrated General Oceanics flowmeter mounted on the frame in front of the net mouth opening. All tows were fished obliquely to a depth of approximately 150m or to about 10m above bottom in shallower waters. Tow depths were primarily derived from a Benthos time-depth recorder (TDR). Occasionally, the TDR did not function. In these cases, default values of 150m and 154m were used based on the mean tow depth at deep survey stations during Leg I and Leg II, respectively. During Leg I, a total of 63 hauls were made during the large-area survey (Survey A), and 16 hauls were made during the cross-shelf transects (Stations X01-X16); Leg II included 67 hauls during the large-area survey (Survey D) and 15 hauls during the cross-shelf transects (Stations X29-X44) (Table 4.1). Three additional IKMT hauls were taken during Survey C on Leg II but are not considered here because of the small sample size.

Shipboard Analyses: Krill collected by the IKMT nets were examined on board to provide information on the relative abundance and composition of stocks encountered during the surveys. All samples of 125 individuals or less were completely analyzed. For larger samples, a minimum of 100 individuals were measured, sexed and staged if only one size mode was present; at least 200 individuals were examined if two size modes were present. Total counts were made for all krill catches. Measurements were made of total length; stages were based on the classification scheme of Makarov and Denys (1981). During Leg I, the larger sized zooplankton constituents (excluding copepods, chaetognaths and pteropods) were sorted from the freshly collected Survey A samples. A total of 25 different taxa were identified and enumerated. Abundance estimates of both krill and those zooplankton are expressed as numbers per meter^2 and numbers per 1000m^3.

4.3 Results & tentative conclusions:

Large-Area Survey A, 19 January-2 February.

Krill: A total of 6120 krill were collected in the 63 IKMT tows made during Survey A; 2592 of these were measured, sexed and staged. Catch size was highly variable and ranged from 0 to 2313 krill with an overall mean abundance of 3.5/m^2 (±11.7) and a median value of 0.9/m^2 (Table 4.1). The catch sizes roughly corresponded to the overall pattern of acoustically detected biomass with largest values to the west and northeast of Elephant Island; greatest abundance (89.1/m^2) was at Station A53 off the northeast tip of the island. Small or no krill catches were characteristic of the area south of Elephant Island (Figure 4.1).

Both the overall krill maturity structure and the size frequency distributions within the Survey A area are greatly biased by the large catch of predominantly small juveniles at Station A53. As a consequence, emphasis is placed here on pooled data (numbers per meter^2) excluding this station to provide a more representative description of the krill demography. The krill were dominated and fairly evenly represented by reproductively mature (43.8%) and juvenile (37.1%) forms, while immature stages made up only 19.1% of the total (Table 4.2). Juveniles generally dominated the larger samples collected within the Weddell-Scotia Confluence (WSC) water mass, which extended from the southwest to northeast of Elephant Island, while mature or mixtures of mature, immature and juvenile stages predominated to the north (Figure 4.1). Males outnumbered females by 1.7:1. Only 54% of the males were mature in contrast to 97% of the females. The majority of the mature females (95%) exhibited early to late stages of ovarian development (stages 3b and 3c); few of these were gravid (2%), and none appeared to have recently spawned. These observations indicated that spawning would not have occurred before February.

The overall size frequency distribution (Figure 4.2) differs from that observed during the past two summer seasons in that it shows two distinct modes. One is an adult mode around 44-45mm, the other a juvenile mode around 28mm. This latter peak indicates successful spawning in the previous (i.e., 1990/91) season. Intermediate sized krill of 35-42mm, which normally represents the 2+ age group, are under-represented.

Three different types of length frequency distributions were observed (Figure 4.3). These were: (a) unimodal juvenile sizes; (b) predominantly large adults; and (c) mixtures of juveniles and adults. The geographical distribution of these size groups is similar to that of the maturity stages (Figure 4.4). The small sizes dominated at stations to the west of Elephant Island and over the island shelf. The large sized krill dominated primarily at stations adjacent to King George Island and at stations offshore of the 2000m isobath. The mixed size classes tended to occur at stations located between those dominated by the small and large krill.

Zooplankton: Twenty-five zooplankton taxa were identified to species level (Table 4.3). Dominant forms aside from krill were salps (*Salpa thompsoni*), the euphausiid *Thysanoessa macrura*, and the amphipod *Themisto gaudichaudii*. *Thysanoessa macrura* was much more abundant than *Euphausia superba*; it was almost ubiquitous in samples and was broadly distributed throughout the survey area with no obvious pattern of abundance (Figure 4.5a). Salps were the most abundant taxon collected; although broadly distributed across the survey area, they had peak abundances (to 207/m^2) east of Elephant Island (Figure 4.5b). Larval fishes were rarely collected; the most abundant species was *Nototheniops larseni*.

Algae: Algae (primarily chain forming diatoms) frequently constituted a significant portion of the IKMT samples. This was most apparent in Drake Passage water to the north of the transition waters and WSC zone where catches ranged from 0.5-9 liters per haul (Figure 4.5c).

Cross-shelf Transects, 3-4 February.

Krill: A total of 2665 krill were collected in the 16 IKMT tows during the cross-shelf transects north of Elephant Island (Table 4.1). The larger catches were made along the eastern transect and at the nearshore stations of the western transect (Figure 4.6). Juvenile and immature stages were equally represented here and together constituted 52% of the catch (Table 4.2). Males outnumbered females by 2.2:1. Mature and immature males were fairly equally represented; 93% of the females were mature.

The size frequency distribution was bimodal but with a larger proportion of large sized individuals than in Survey A (Figure 4.7). As in Survey A, three size categories dominated the catches. These were the large, small and mixed sizes. Also, one station (X06) was dominated by the rarely encountered intermediate sized immature class.

Large-Area Survey D, 29 February-9 March.

Krill: A total of 10867 krill were collected in the 68 IKMT tows made during Survey D; 3646 of these were used for demographic studies. Catch size ranged from 0 to 2139 krill, with an overall mean abundance of 6.0/m^2 ($\pm$12.0) and a median value of 1.1/m^2 (Table 4.1). Relatively large catches occurred at scattered locations around Elephant Island (Figure 4.8). The largest catches were made between Elephant and King George Islands at Stations D23 (70.2/m^2) and D09 (42.1/m^2); the third largest catch (36.5/m^2) was northeast of Elephant Island at Station D66.

As during Leg I the krill were dominated by reproductively mature (39.2%) and juvenile (33.6%) forms; however, immature stages constituted a greater proportion (27.1% vs. 19.1%) than during the previous leg. This difference was largely due to increased relative abundance of immature males (Table 4.2). Mature stages generally dominated samples collected in Drake Passage waters, while juveniles, immature stages and mixed maturity stages were characteristic of the water masses to the south (Figure 4.8). The male to female ratio (1.5:1) was similar to that of Survey A. Most of the females were mature, but the majority of these (78.5%) were in earlier stages of development (3a and 3b) than observed during the previous month; less than 5% were gravid or had recently spawned.

The overall size frequency distribution (Figure 4.9) differs significantly from that of Survey A due to greater proportions of intermediate sized krill and reduced proportions of smaller sizes (Kolmogorov-Smirnov test, $P < 0.01$). Four size frequency distributions were apparent (Figures 4.10 a-d). These included predominantly (a) small, (b) intermediate, (c) large size categories, and (d) mixtures of these. The intermediate 35-42mm size category contributed 34.3% of the total estimated abundance vs. 18.8% during Survey A; smaller sizes contributed 28.6% vs. 44.7% during Survey A. Proportions of the large sized krill were similar during both large-area surveys (ca. 37%). Small sized krill were relatively abundant and dominant only in the southern portion of the survey area, while the large sizes generally dominated in Drake Passage water. Intermediate sized krill primarily occurred south of Drake Passage water in the eastern portion of the survey area in association with eastern Bransfield Strait, WSC and transition water masses (Figure 4.11).

Cross-shelf Transects, 10-12 March.

Krill: A total of 2752 krill were collected in the 15 tows during the cross-shelf transects. The mean and median abundance values were similar to those during the Leg I cross-shelf transects (Table 4.1). Greatest abundance ($51.2/m^2$) occurred at Station X34 off the northwest tip of the island; the other catches were comparatively small (0.2-$10.5/m^2$) (Figure 4.12). Because of bias due to its large size, Station X34 is excluded from considerations of the pooled cross-shelf transect data. Juveniles and mature stages dominated the other samples (81.6%). Females slightly outnumbered males; over half of the mature females were in the early 3a maturity stage. The overall size frequency distribution shows a mixture of small, intermediate and large size categories (Figure 4.13).

4.4 Disposition of data and samples: All of the krill demography data and large zooplankton data have been digitized and are available upon request from Loeb (krill) and Wormuth (zooplankton). The krill will be sent to the Southwest Fisheries Science Center for storage. With the exception of larval fishes, the identified zooplankton taxa were returned to the sample jars along with the unidentified forms and will be sent to Texas A&M University (Wormuth) for further detailed analysis The larval fishes will be sent to Moss Landing Marine Laboratories (Loeb) for further analysis and inclusion in the long term AMLR ichthyoplankton collection and data base. Myctophids collected by the IKMT have been frozen and will be sent to Donald Croll at the National Marine Mammal Laboratory.

4.5 Problems and suggestions: Chronic problems exist with regards to a suitable, reliable time-depth recorder. We have twice attempted to use modern electronic depth recording devices, but these have failed and we have had to rely on an aged and quasi-reliable mechanical device. We need to come up with a satisfactory solution. Persistent problems also occurred with the winch meter readout display, and we often had to fish our IKMT tows blind with no information on wire speed out and in or meters of wire out. This is unacceptable for making standard tows. A backup metered block is also needed.

The 6' IKMT fitted with plankton mesh is a great improvement over the bongo nets used in past AMLR surveys. With it we are able to obtain adequate quantities of krill and also collect representative zooplankton samples. Shipboard analysis proved to be effective way of assessing krill distributional patterns relative to hydrographic conditions in a more or less real-time manner and should be continued. Similar shipboard analysis of the larger zooplankton, as was done during this cruise, is highly recommended in the future. If so, it would be advantageous to have additional personnel to help with sample processing and analysis.

Table. 4.1 AMLR1992 krill catches and abundance estimates based on IKMT hauls made during each survey.

LEG I:	Survey A				Cross-shelf transect			
	# tows	# krill	#/m2	#/1000m3	# tows	# krill	#/m2	#/1000m3
Total	63	6120			16	2665		
Median		25	0.9	5.7		27	1.2	7.6
Average		97	3.5	23.7		167	6.0	47.4
STD		311	11.7	78.0		233	8.0	67.3
Maximum		2313	89.1	594.1		719	26.9	205.7
Minimum		0	0.0	0.0		0	0.0	0.0

LEG II:	Survey D				Cross-shelf transect			
	# tows	# krill	#/m2	#/1000m3	# tows	# krill	#/m2	#/1000m3
Total	67	10867			15	2752		
Median		25	1.1	7.1		32	1.3	10.8
Average		162	6.0	38.0		183	6.2	42.2
STD		365	12.0	77.4		395	12.4	82.5
Maximum		2139	70.2	389.9		1628	51.2	341.7
Minimum		0	0.0	0.0		4	0.2	1.0

Table 4.2 AMLR1992 krill maturity stage composition based on summed numbers per m2 from IKMT hauls taken during each survey.

	LEG I: Survey A (minus A53)			Cross-shelf transect			LEG II: Survey D			Cross-shelf transect (minus X34)		
	# krill	%	%	# krill	%	%	# krill	%	%	# krill	%	%
Juveniles	712	37.1		352	26.4		1205	33.6		310	37.7	
Immature	449	19.1		251	25.7		779	27.1		153	18.3	
Mature	1311	43.8		357	47.9		1662	39.2		389	43.9	
Total	2472			960			3646			852		
Males	1043	39.8		445	50.4		1506	39.6		267	29.7	
Females	717	23.5		163	23.2		935	26.8		275	32.6	
Male:Female ratio	1.7:1			2.2:1			1.5:1			0.9:1		
Immature males	425	18.2		235	24.0		747	26.4		147	17.7	
Mature males	618	21.5		210	26.4		759	13.2		120	12.0	
Immature females	24	0.8		16	1.7		32	0.8		6	0.6	
Mature females (3a)	18	0.7	2.9	4	0.4	2.0	301	10.3	39.4	147	18.7	58.5
Mature females (3b)	371	12.3	54.4	96	13.3	62.1	359	10.2	39.1	64	6.7	20.9
Mature females (3c)	287	9.2	40.8	47	7.7	36.0	152	4.3	16.7	49	5.5	17.3
Mature females (3d)	17	0.4	2.0	0	0.0	0.0	88	1.2	4.6	5	0.5	1.7
Mature females (3e)	0	0.0	0.0	0	0.0	0.0	3	<0.01	0.1	4	0.5	1.6

Table 4.3 Larger zooplankton taxa identified in the AMLR1992 Survey A samples.

	Total #	Numbers per m2			
		Mean	Std. Dev.	Max.	Median
Euphausia superba	6032	3.5	11.7	89.1	0.9
Euphausia frigida	1406	0.9	2.4	13.7	
Euphausia triacantha	126	0.1	0.3	2.1	
Thysanoessa macrura	15023	8.8	10.6	41.4	3.3
Themisto gaudichaudii	4836	2.8	6.4	44.4	1.2
Cyllopus lucasii	662	0.4	0.8	3.4	
Cyllopus magellanicus	194	0.1	0.8	6.1	
Vibilia antarctica	259	0.2	0.3	1.4	
Primno macropa	25	0.0	0.0	0.2	
Hyperoche medusarum	4	0.0	0.0	0.0	
Hyperiella dilatata	38	0.0	0.0	0.1	
Antarctomysis maxima	4	0.0	0.0	0.2	
Atolla wyvillei	2	0.0	0.0	0.0	
Periphylla periphylla	2	0.0	0.0	0.0	
Diphyes antarctica	6	0.0	0.0	0.1	
Tomopteris carpenteri	473	0.2	0.5	3.2	
Vanadis antarctica	17	0.0	0.0	0.1	
Salpa thompsoni	28584	16.6	32.8	206.7	2.3
Nototheniops larseni larvae	29	0.0	0.0	0.2	
Notolepis sp. larvae	5	0.0	0.0	0.2	
Electrona antarctica larvae	4	0.0	0.0	0.1	
Racovitzia glacialis larvae	1	0.0	0.0	0.0	
Notothenia gibberifrons larvae	1	0.0	0.0	0.1	
Harpagifer sp. larvae	1	0.0	0.0	0.0	
Notothenia kempi larvae	6	0.0	0.0	0.1	

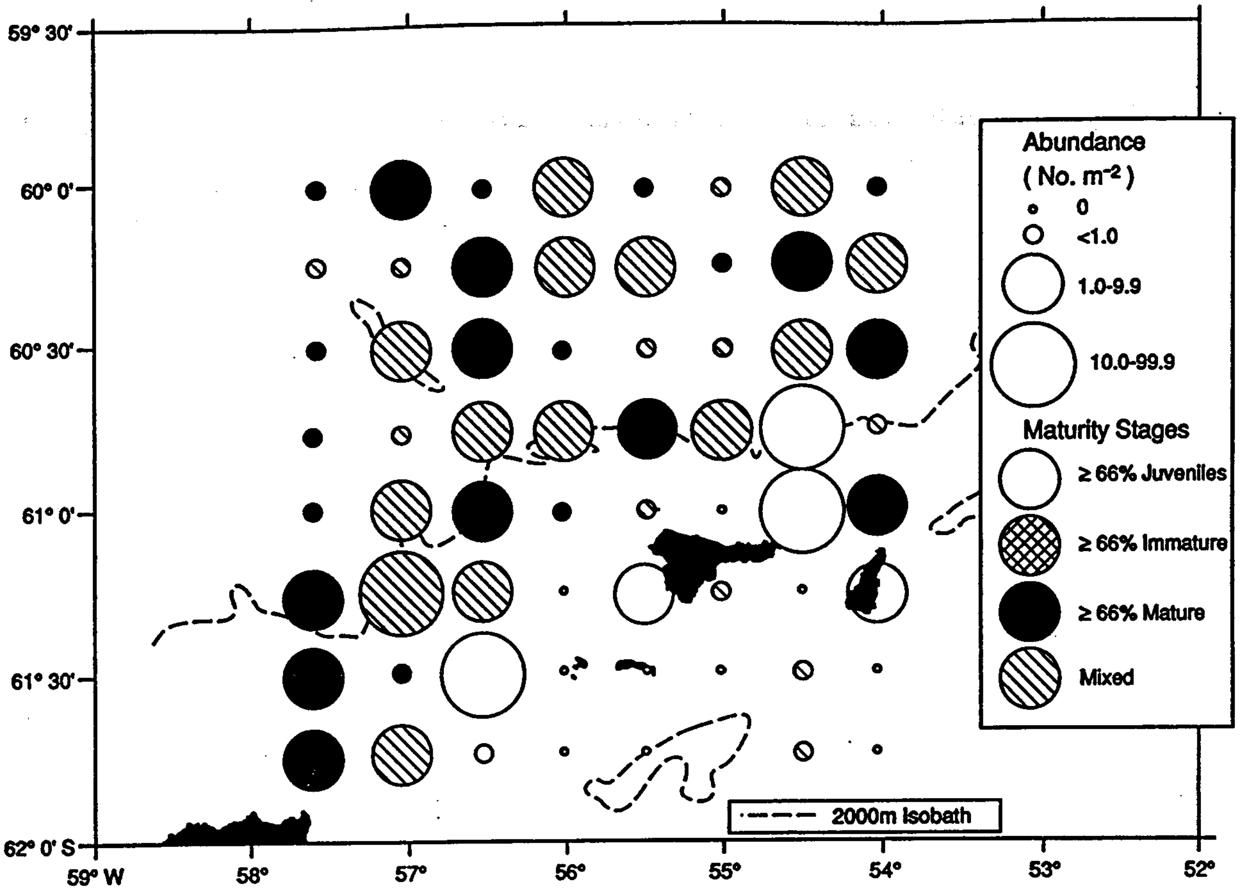

Figure 4.1 Krill abundance and maturity stage composition during Survey A.

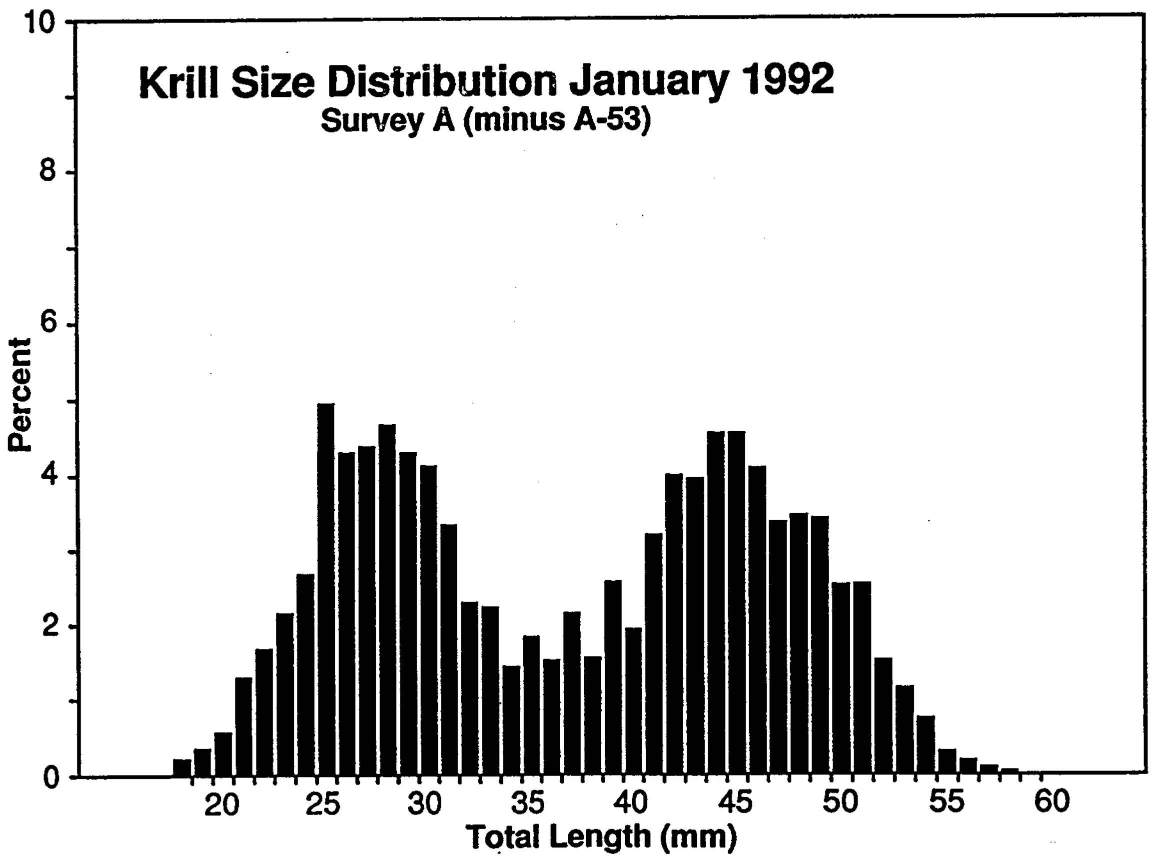

Figure 4.2 Overall size frequency distribution of krill collected during Survey A.

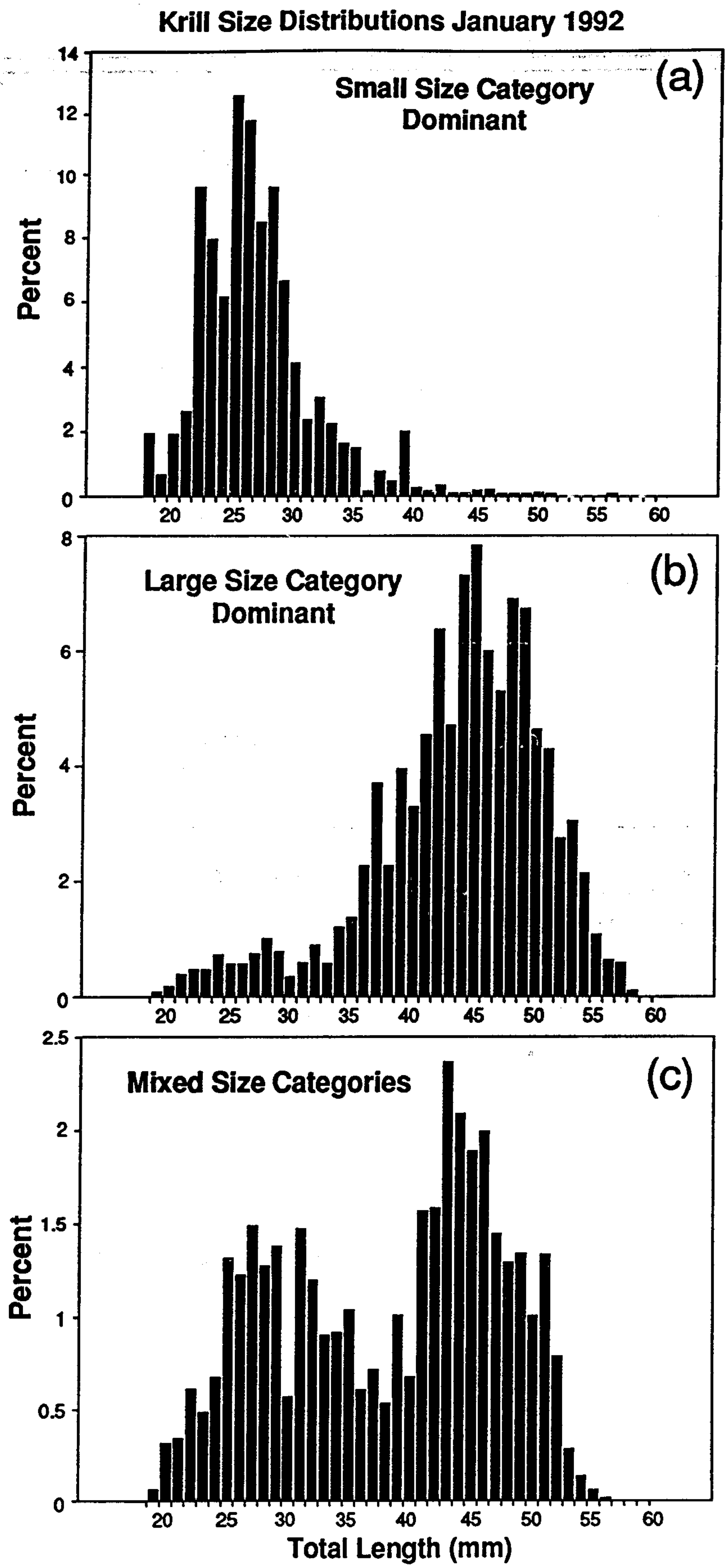

Figure 4.3 Types of size frequency distributions observed in Survey A samples. (a) Small size category dominant. (b) Large size category dominant. (c) Mixed size categories.

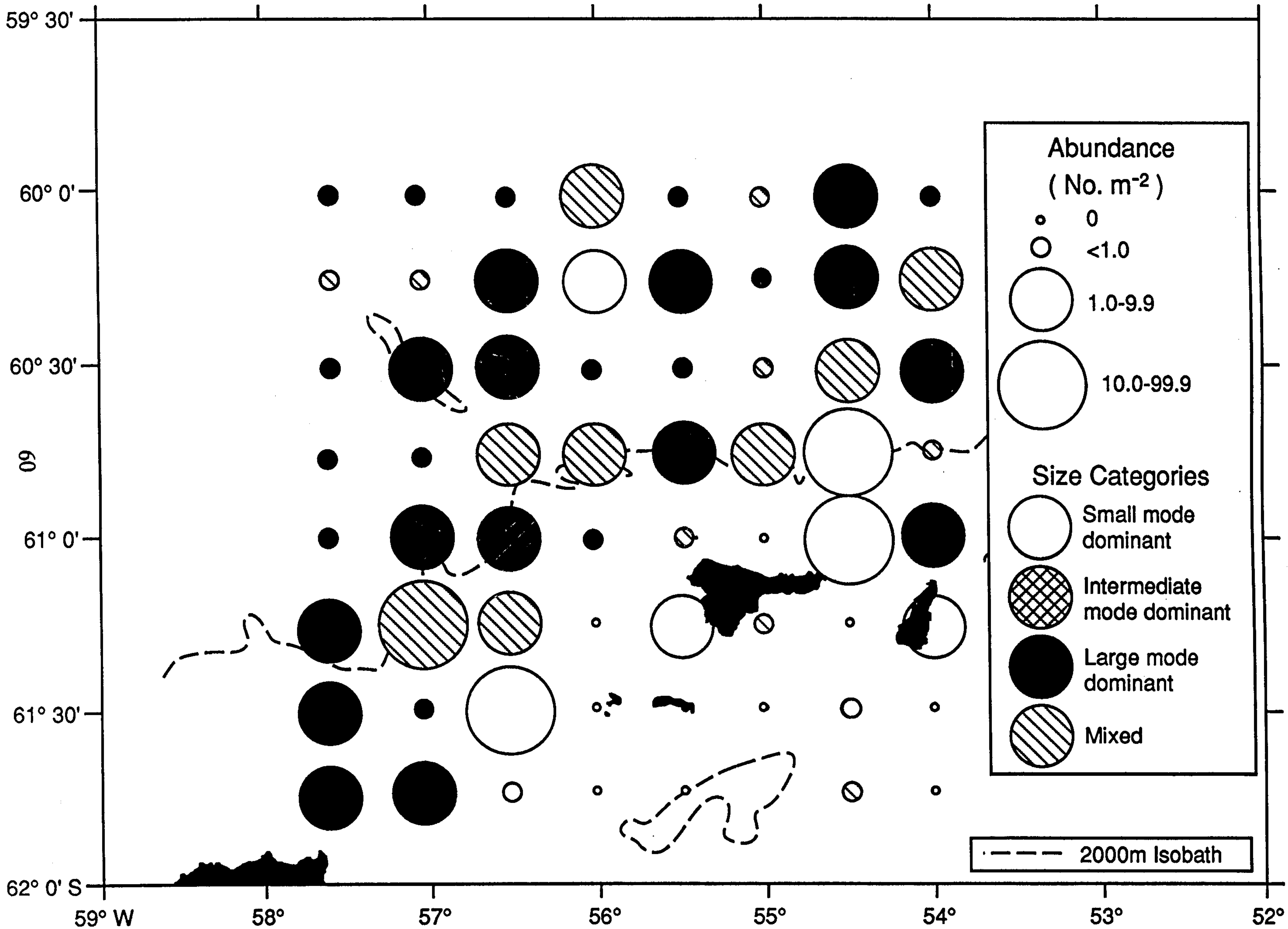

Figure 4.4 Distribution of size categories in the Survey A area.

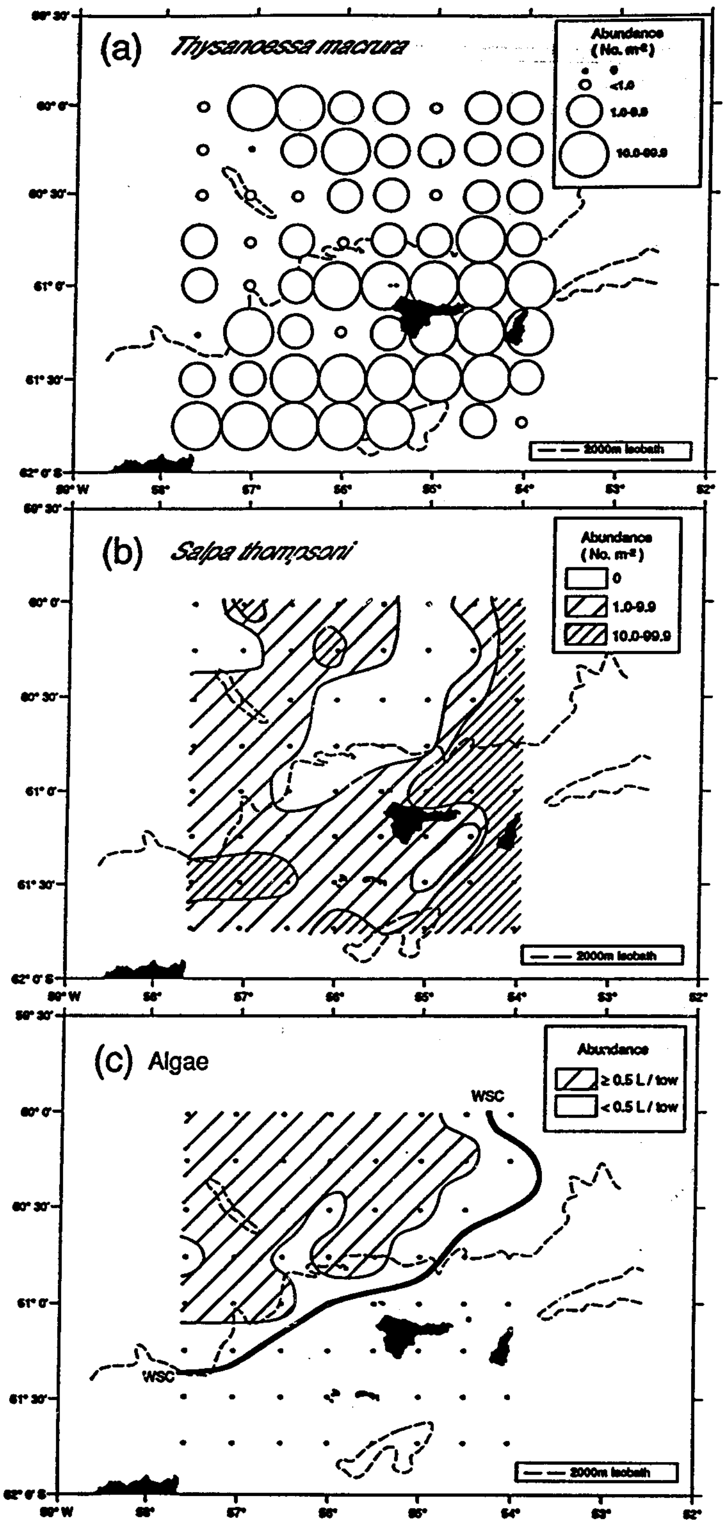

Figure 4.5 Distribution of (a) *Thysanoessa macrura*, (b) *Salpa thompsoni*, and (c) algae in the Survey A area.

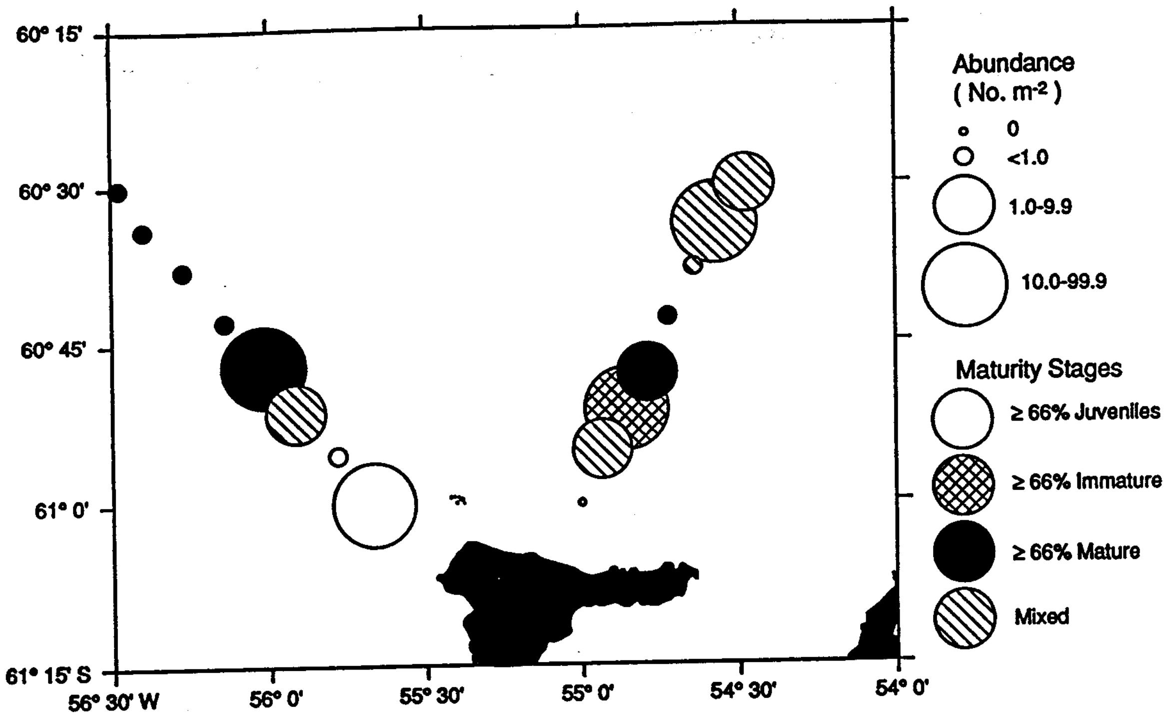

Figure 4.6 Krill abundance and maturity stage composition in the Leg I cross-shelf transect.

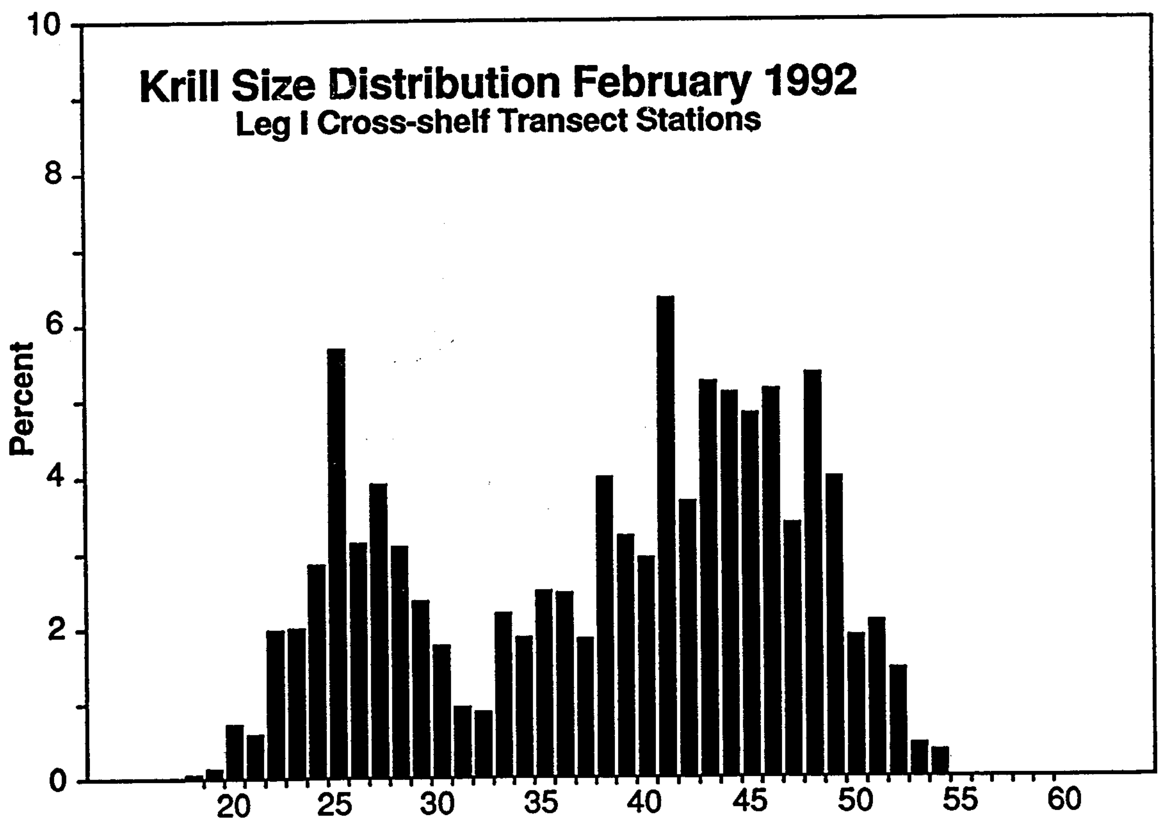

Figure 4.7 Overall size frequency distribution in krill in the Leg I cross-shelf transect.

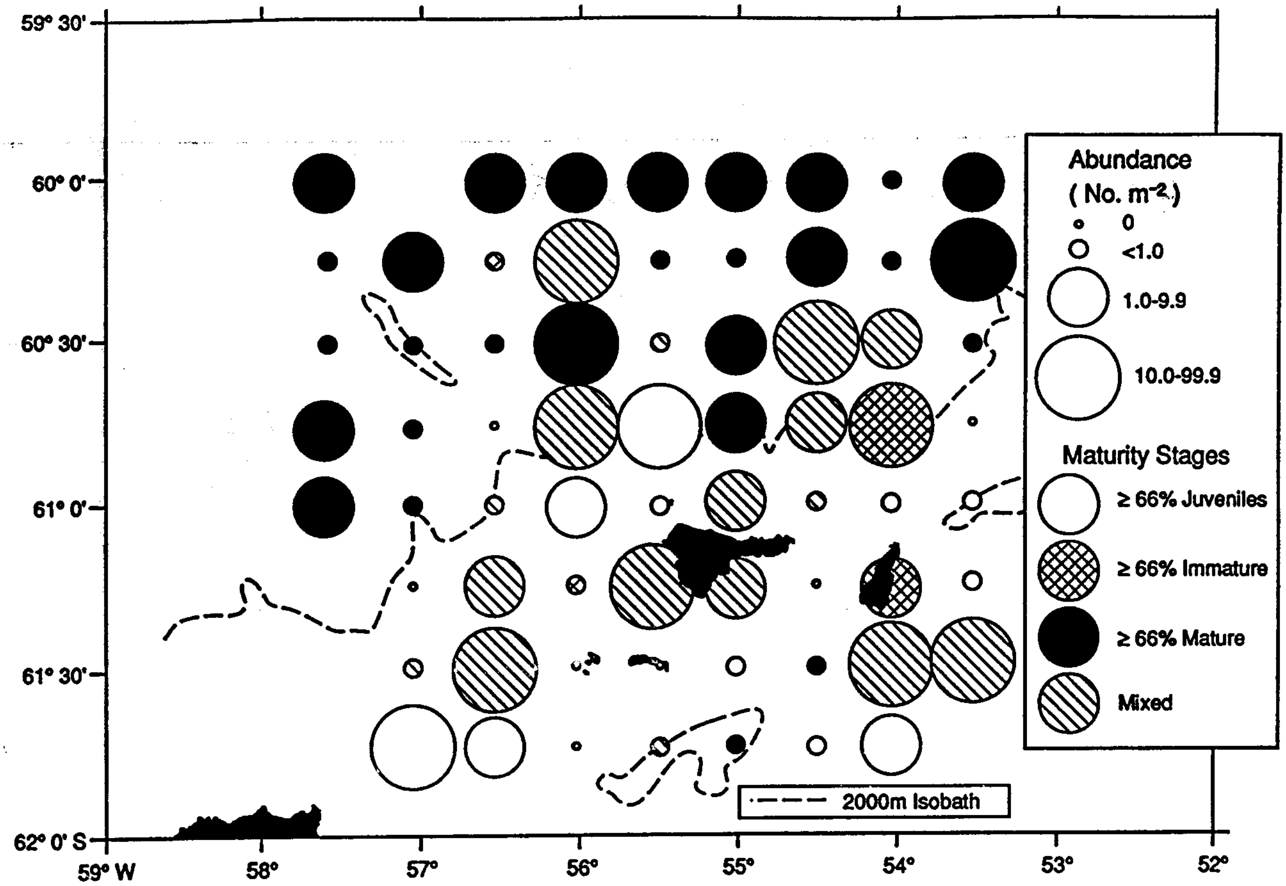

Figure 4.8 Krill abundance and maturity stage composition during Survey D.

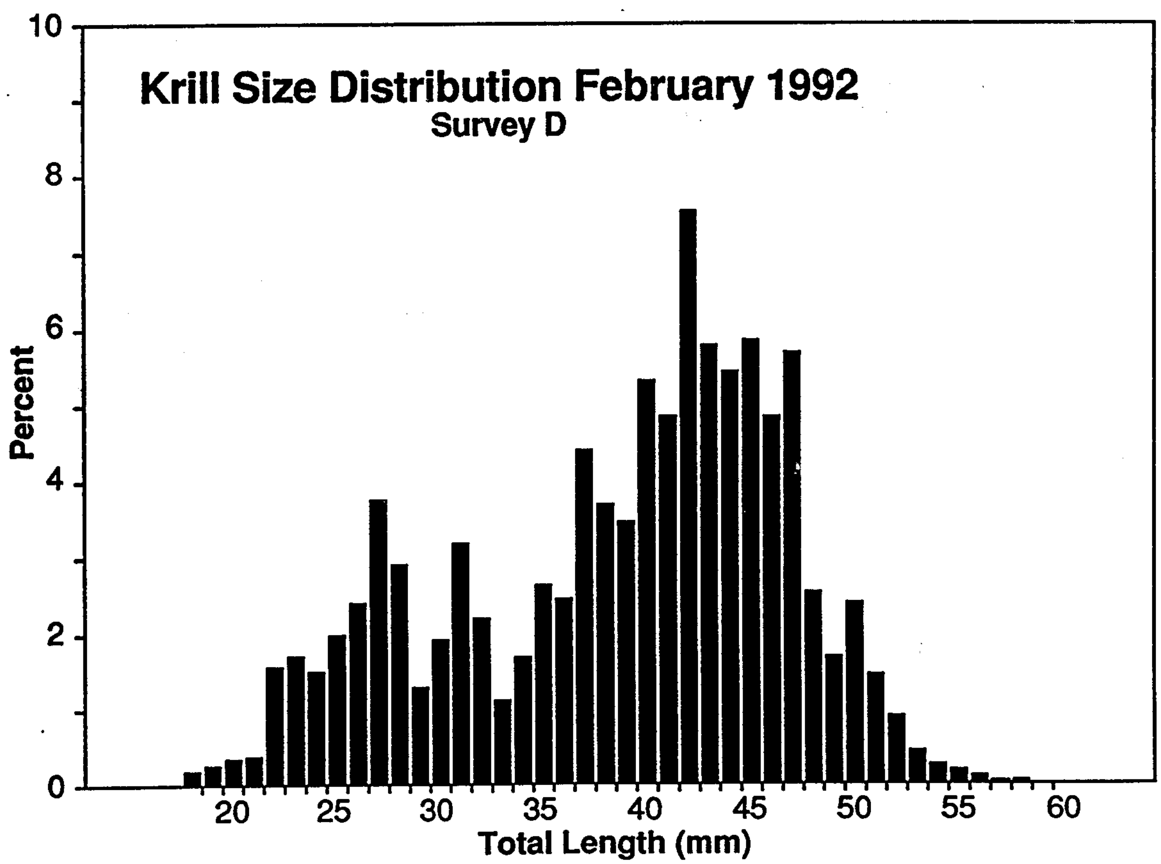

Figure 4.9 Overall size frequency distribution of krill collected during Survey D.

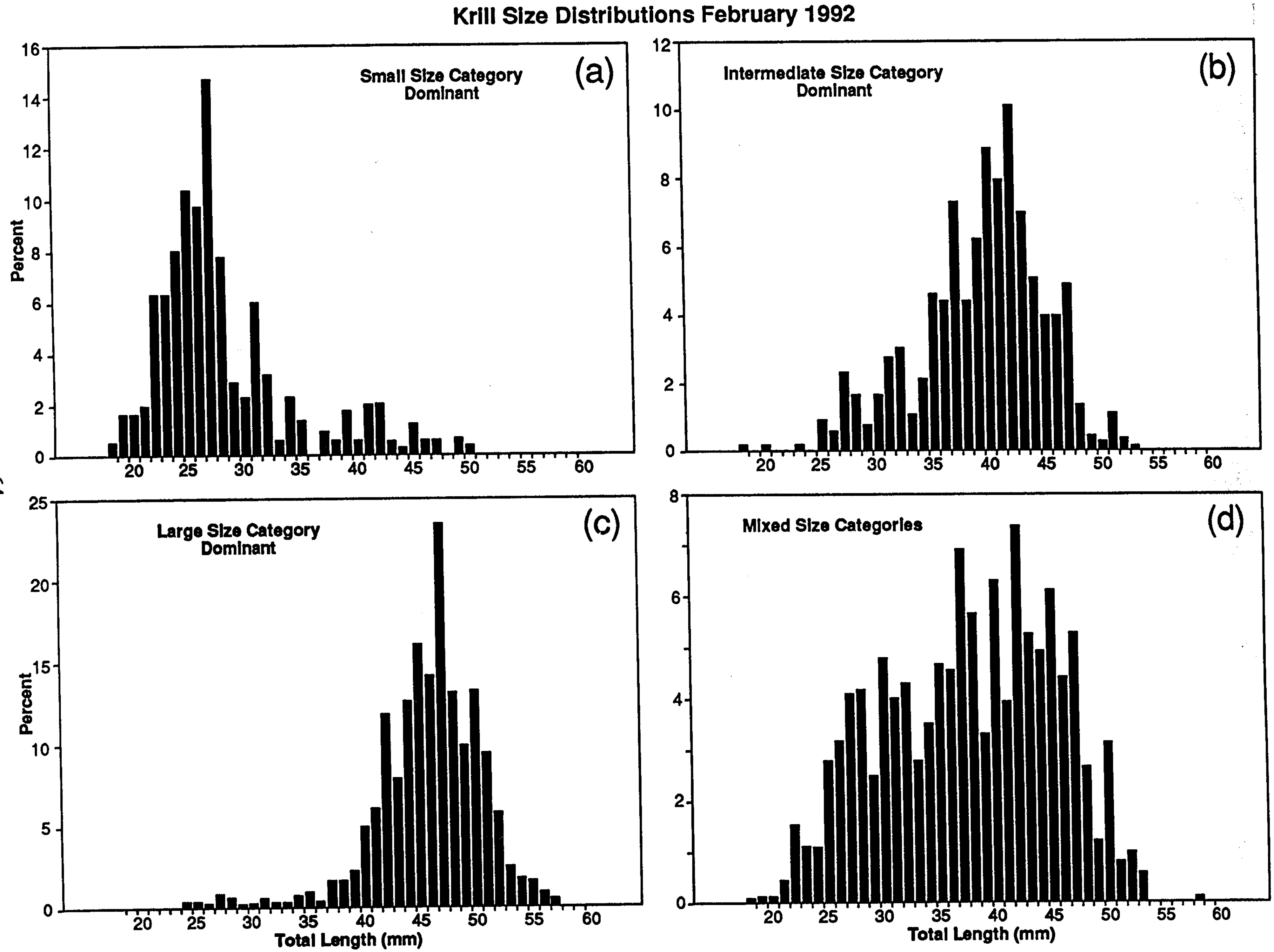

Figure 4.10 Types of size frequency distributions observed in Survey D samples. (a) Small size category dominant. (b) Intermediate size category dominant. (c) Large size category dominant. (d) Mixed size categories.

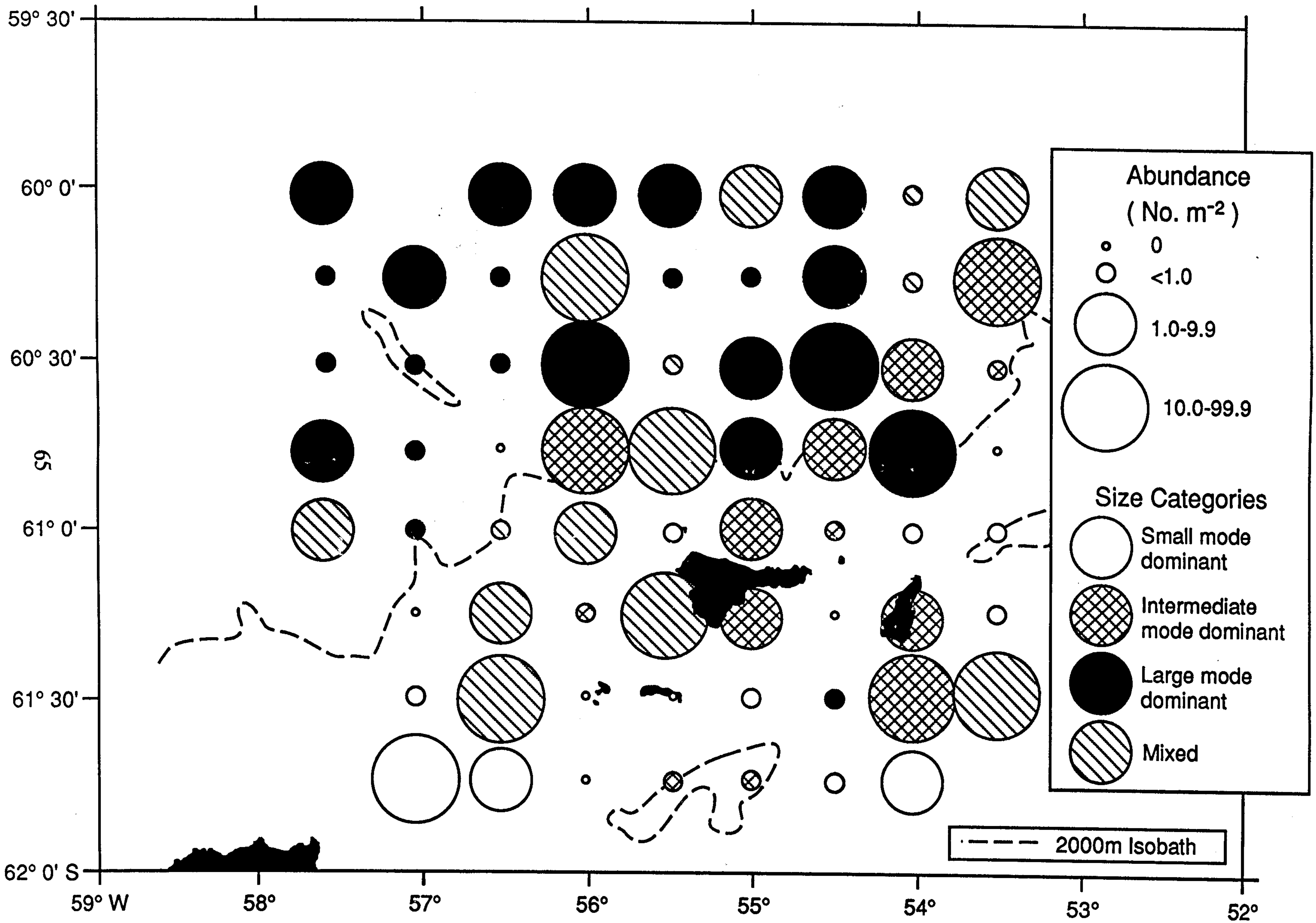

Figure 4.11 Distribution of size categories in the Survey D area.

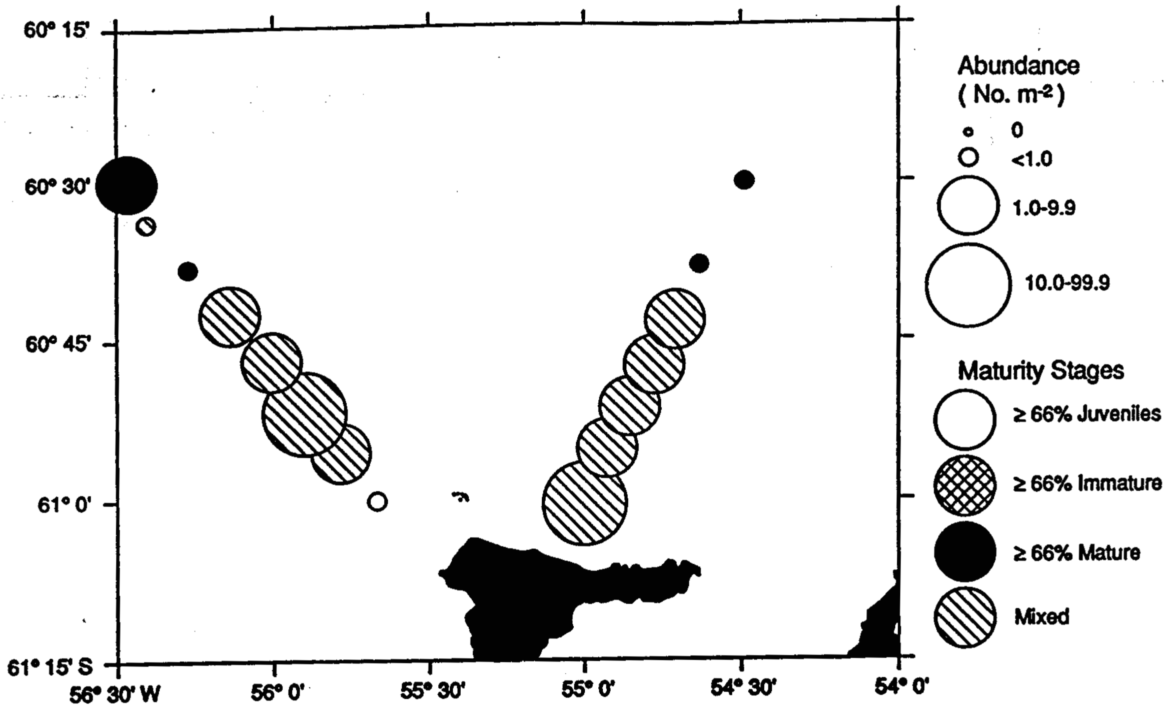

Figure 4.12 Krill abundance and maturity stage composition in the Leg II cross-shelf transect.

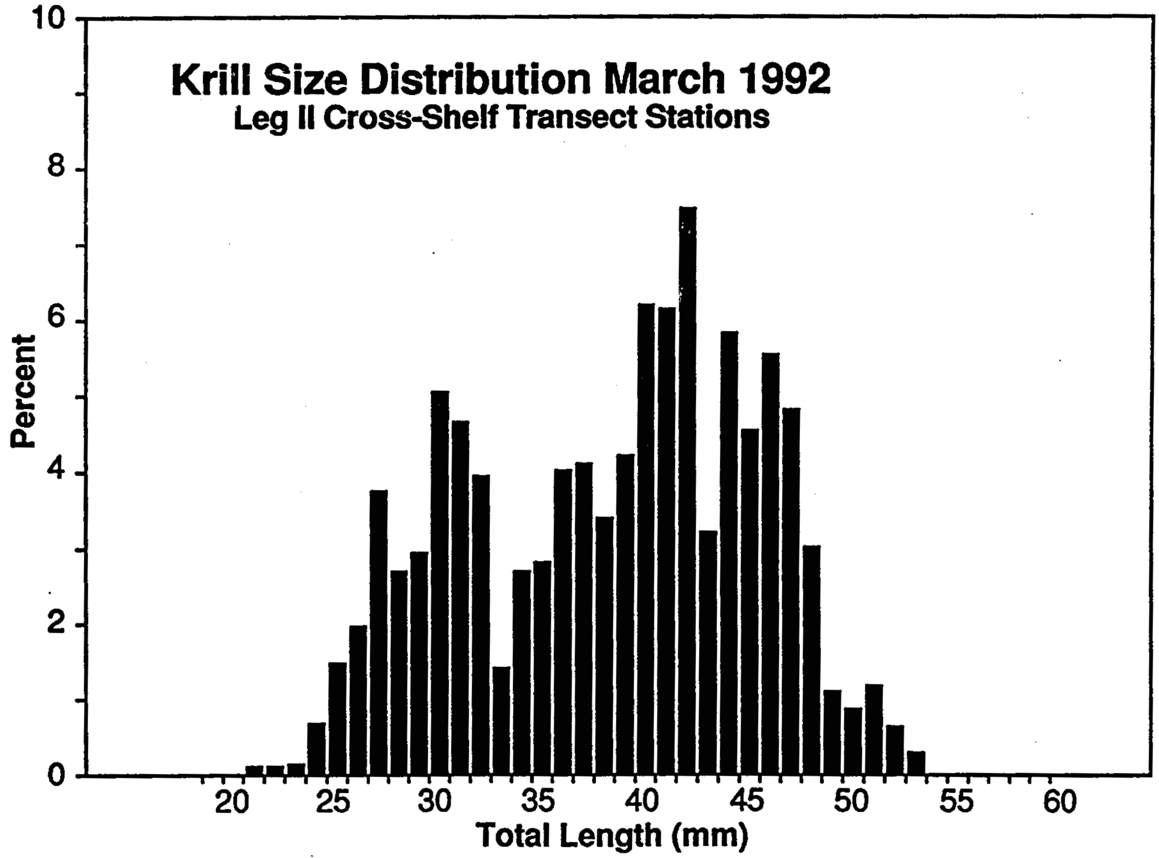

Figure 4.13 Overall size frequency distribution of krill in the Leg II cross-shelf transect.

5. Zooplankton, Leg I (MOCNESS); submitted by John H. Wormuth, Marilyn Yeager, and Luiz Fernandes, Texas A & M University.

5.1 Objectives: The primary objective of this study was to sample krill concentrations located by acoustic surveys on horizontal scales of 100-400m and on vertical scales of 5-25m using a 1m MOCNESS (Multiple-Opening-Closing-Environmental-Sampling-System). A secondary objective was to sample other acoustic targets using a MOCNESS in order to determine their composition. Lastly, a third objective was to sample zooplankton and nekton using an IKMT in both a large-area survey centered on Elephant Island and cross-shelf transects north of the island.

5.2 Accomplishments:

MOCNESS: Fine-scale MOCNESS sampling was conducted to examine the vertical and horizontal distribution of acoustic targets in four areas identified as likely to have high krill concentrations based on the results from Survey B (Figure 5-Introduction). The MOCNESS sampling was conducted over a four day period and consisted of 20 MOCNESS tows taken in the four areas. Four tows were taken in Area A (3 Day, 1 Night), two in Area B (1 Night, 1 Transitional {Dawn or Dusk}), five in Area C (3 Day, 1 Night, 1 Transitional) and nine in Area D (5 Day, 2 Night, 2 Transitional). The MOCNESS sampling was conducted during the last portion of Leg I; therefore, the sample analysis presented here is very preliminary. Each sample was grossly characterized based on the visibly dominant groups. The krill in each sample were counted if there were <40-50 individuals. If there were more, counts were only estimated in intervals of 100, 500 or >1000. Actual counts will have to await lab analysis. Simultaneous measurements of acoustic backscattering strength displayed on a color monitor (part of the acoustic system, see Section 3) were also characterized, where red color denotes highest density of acoustic targets, green and yellow intermediate density, and blue low density (Table 5.1).

The depth intervals sampled during each MOCNESS deployment were adjusted to sample above, below, and within acoustic targets that were seen on the color monitor. In some cases, no targets appeared on the monitor; the nets were then fished in the upper 200m to provide gross characterization of the zooplankton. Whenever possible, a discrete net was fished above the depth of the acoustic towed body so that the portion of the water column invisible to the acoustic system could be sampled.

IKMT: Samples were collected at 64 stations in the large-area survey (Survey A) and 16 stations in cross-shelf transects using a 6' IKMT. Krill were separated from the samples for analysis by V. Loeb (see Section 4). The non-krill portions of the samples were preserved and will be analyzed in the lab at a later date. Some samples consisted of dense phytoplankton, and it was necessary to use a serial dilution procedure to separate out the zooplankton. Some samples had high salp concentrations, and these had to be subsampled. This was done using calibrated buckets; samples were diluted to 7, 8 or 12 liters and then a one liter subsample was removed. During Leg I, macrozooplankton species (excluding copepods, chaetognaths and pteropods) were identified and counted by V. Siegel (see Section 4).

5.3 Results:

MOCNESS: In Area A, there was no algae in the samples. Acoustic targets were represented by blue clusters only on the color monitor. In the only night tow, we caught a large biomass of juvenile krill in the 0-25m net and in the oblique net towed from depth to the surface. There were no acoustic targets on the color monitor during the night tow. It is possible that these juvenile krill were near the surface, above the level of the acoustic towed body. The day tows in Area A had mixed krill, with the larger krill being deeper in the water column and juvenile krill near the surface. Salps dominated horizontal layers from 30-40m with catches from 7-12 liters. Area B also had no algae. Juvenile krill dominated the samples with very large catches, corresponding with red, yellow and green targets on the color monitor. Area C was characterized by algae in the upper nets from 0-25 and 25-50m. The krill were larger (40-50mm). Salps were in the majority of the nets. In Area D, the krill were larger in general with occasional mixed sizes. Salps were present in 9 of 72 samples.

A definitive presentation of distributional patterns, both horizontally and vertically, will have to await lab analysis. It is, at present, not possible to identify and count smaller zooplankton while at sea. Several things can be said, however, about the MOCNESS samples as they relate to the acoustic targets seen on the acoustic system's color monitor:

1. Scattered, diffuse blue targets were usually heavy salp concentrations.

2. More discrete layers, particularly vertically, of all colors were krill (dominant sizes and mixtures of sizes varied).

3. While krill were always caught in varying numbers when acoustic targets were seen on the monitor, there were samples where >1/m3 were caught when there were no acoustic targets. These were generally in samples covering, in part, the upper 25m and may have been from levels above the acoustic towed body.

4. While avoidance of towed nets is indisputable, the degree of avoidance appears not to be related to the size of the net (at least from $1m^2$ to $10m^2$) but may be more influenced by the concentration of the krill.

5.4 Disposition of Samples: The non-krill portion of all IKMT tows and all of the MOCNESS samples will be sent to Texas A&M University. The environmental data (temperature, depth, salinity) will be available on DOS formatted discs following translation from HP DOS. Final data will also be on DOS discs in either QuatroPro of Excel spreadsheets.

5.5 Recommendations: (a) As previously stated, net size seems to have less effect on reducing avoidance than previously thought. The other important variable to consider is speed of tow. The use of the depressor vane on the MOCNESS has shown that tow speeds of up to four knots do not significantly effect towing angle. We think the vane should be used even though it complicates things in the limited deck area available.

(b) It is strongly recommended that program management consider using the MOCNESS as a routine net for the large-area survey. It has proven itself to be reliable, as easy to deploy and recover as the IKMT, and provides environmental data as well. Sampling time could be equal to the IKMT, and sample numbers could be kept small by using only a few nets.

The following are minor recommendations:

(c) An extension of the ship's PA system should be put in the van so personnel in that area could be alerted to the arrival of a station, etc.

(d) We recommend that the conducting cable be used for a more accurate and reliable depth sensing system for the large-area survey.

(e) There should be some type of communication between the acoustic towed body and the MOCNESS to determine actual depth, relative depth and distance between them.

(f) If the IKMT is used for survey stations and MOCNESS for directed sampling, the termination for the MOCNESS should be done after the trawl sampling, not before. This gives more clearance for the winch operator and eliminates the chance of severing the electrical cable to the MOCNESS.

(g) We suggest a lip be put on the edges of the counters in the lab van, as well as vertical supports in mid-shelf sections.

(h) We recommend that the program continue to provide space next to the acoustic system's color monitor for the MOCNESS controls. This is invaluable in making real-time decisions on sampling strategy.

Table 5.1 : MOCNESS data summary for AMLR 1992 stations.
Note: depths shown are target depths, not the actual depth sampled.
Each depth must be corrected for offset of acoustic bomb and pressure monitor

Moc 150 M 01 Night 03:04 Area A Init. 60 57.46S Init. 055 05.89W Fin. 61 00.75S Fin. 055 07.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	500	330	1.515	no acoustic targets	juvenile krill
2	25-50	0	186	0.000	no acoustic targets	salps, T. macrura and copepods
3	50-75	0	276	0.000	no acoustic targets	salps, T. macrura and copepods
4	75-100	0	315	0.000	no acoustic targets	T. macrura and copepods
5	100-125	0	439	0.000	no acoustic targets	T. macrura and copepods
6	125-150	0	206	0.000	no acoustic targets	T. macrura and copepods
7	150-175	0	240	0.000	no acoustic targets	huge chaetognaths, T. macrura and copepods
8	175-200	0	229	0.000	no acoustic targets	huge chaetognaths, T. macrura, cop. and amphi
9	200-0	3000	2041	1.470	no acoustic targets	50:50 salps and juvenile krill

Moc 151 M 02 Day 12:56 Area A Init. 60 58.91S Init. 055 13.00W Fin. 61 00.29S Fin. 055 19.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	500	971	0.515		juvenile krill and few salps
2	25-50	100	597	0.168		juvenile krill
3	50-75	100	579	0.173	few blue dots	mixed krill and salps
4	75-100	0	741	0.000	blank screen	large salps and amphipods
5	100-75	0	566	0.000	blank screen	small sample, mixed zooplankton
6	75-50	0	490	0.000	scattered blue individual dots	same as above plus 1 jellyfish
7	50-25	0	444	0.000	blue double and single dots	small sample, mixed zooplankton
8	25-15	13	338	0.038		salps, juvenile krill and amphipods
9	15-0	2	350	0.006		small sample, 2 juvenile krill

Moc 152 M 03 Day 16:14 Area A Init. 60 59.75S Init. 055 13.75W Fin. 61 00.98S Fin. 055 19.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-75	50	540	0.093	no target	mixed krill and zooplankton
2	75-125	1	72	0.014	dense patch	small sample and fish larvae
3	125-150-125	30	468	0.064	no target, acoustic target 160-165m	small sample, mixed krill and salps
4	125-50	1	691	0.001	no target	small sample, salps and amphipods
5	horiz. 50	8	653	0.012	horizontal tow, no targets	small sample, juvenile krill and mixed zooplankton
6	horiz. 50	10	671	0.015	scattered targets above blue cluster	small sample, juvenile krill
7	horiz. 50	1	669	0.001	scattered blue individual dots	small sample, siphonophores
8	50-25	0	446	0.000	scattered blue individual dots	small sample, chaetognaths, copepods, pteropods
9	25-0	1	265	0.004	scattered blue individual dots	small sample, miscellaneous zooplankton

Moc 153 M 04 Day 20:13 Area A Init. 60 59.01S Init. 055 04.00W Fin. 61 00.44S Fin. 055 08.56W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	0	415	0.000	coming into blue layer	salps
2	25-40	0	787	0.000	dense blue cluster	7 liters of salps
3	40-30	0	452	0.000	dense blue cluster	12 liters of salps
4	30-30	0	293	0.000	dense blue cluster	12 liters of salps
5	30-100	0	268	0.000	few single dots below blue layer	salps, T. macrura and amphipods
6	100-50	1	440	0.002	few single dots below blue layer	same as above
7	50-25	0	244	0.000	bottom of blue layer	8 liters of salps
8	25-7	0	165	0.000	passing through blue layer to above the layer	salps, T. macrura
9	7-0	0	200	0.000	above the acoustic bomb	salps

Moc 154 M 05 Dusk 00:41 Area B Init. 61 01.99W Init. 054 45.09W Fin. 61 02.92S Fin. 054 50.03W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-50	50	1072	0.047	blank screen	medium krill and salps
2	50-75	0	382	0.000	scattered single blue dots	mostly salps
3	75-100	1	361	0.003	scattered single blue dots	salps
4	100-200-100	0	1596	0.000	blank screen	salps and T. macrura
5	100-75	0	235	0.000	blank screen	salps and T. macrura
6	75-50	0	261	0.000	blank screen	salps and T. macrura
7	50-25	20	240	0.083	scattered blue dots	mixed krill and salps
8	25-10	300	481	0.624	red target to green blue dense	large salps, 5 large krill, rest juveniles
9	10-0	10	241	0.041	above the acoustic	salps

Table 5.1 : MOCNESS data summary for AMLR 1992 stations.
Note: depths shown are target depths, not the actual depth sampled.
Each depth must be corrected for offset of acoustic bomb and pressure monitor

Moc 155 M 06 Night 02:37 Area B Init. 61 02.41S Init. 054 45.00W Fin. 61 02.87S Fin. 054 48.50W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	200	311	0.643	blue/green dense target	mixed krill
2	25-50	750	191	3.927	bl/gn dense target w/ solid yellow area	50:50 salps and mixed krill
3	50-25	1000	331	3.021	same as above	juvenile krill and few salps
4	25-7	2000	199	10.050	solid red and yellow	juvenile krill
5	7-25-15	2000	310	6.452	same as above	juvenile krill and many molts
6	horiz. 15	1000	146	6.849	green/yellow/red dense area	juvenile krill and some salps
7	horiz. 15	1000	150	6.667	same as above	juvenile krill only and molts
8	horiz. 15	100	170	0.588	red/yellow, fading intensity	juvenile krill and salps, molts abundant
9	15-0	500	339	1.475	above the acoustic bomb	juvenile krill and some salps

Moc 156 M 07 Day 22:18 Area C Init. 60 52.52S Init. 055 53.64W Fin. 60 53.54S Fin. 055 53.70W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	0	652	0.000	scattered blue targets	salps
2	25-50	0	193	0.000	scattered blue targets	salps
3	50-75	0	350	0.000	no targets	small sample
4	75-100	1	425	0.002	scattered blue (70-90 m)	1 large krill
5	100-200-100	4	1296	0.003	no targets, blue/green at 75 m.	small salps and mixed krill
6	100-50	46	783	0.059	blank 100-75m , scattered targets 75-50 m.	krill (40-50mm)
7	50-25	4	374	0.011	scattered blue targets, weak	krill (45-50mm) , some algae
8	25-10	0	252	0.000	scattered blue targets, weak	algae
9	10-0	0	368	0.000	above the acoustic bomb, no targets below bomb	algae

Moc 157 M 08 Night 02:26 Area C Init. 60 51.47S Init. 055 46.00W Fin. 60 53.41S Fin. 055 52.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	22	225	0.098	blue scatterd clusters	mixed krill, salps and amphipods
2	25-50	*	205	0.000	less dense blue targets	lost cod end in the net during sampling
3	50-75	0	151	0.000	individual blue dots	3 salps and amphipods
4	75-100	6	399	0.015	no acoustic targets	
5	100-200-100	1	1783	0.001	no acoustic targets	salps, T. macrura and amphipods
6	100-50	20	808	0.025	blank except for scattered dots at 50-75m	krill (30-40mm) and salps
7	50-25	1	425	0.002	scattered blue dots	salps
8	25-10	35	310	0.113	fewer scattered blue dots, dense target 0-20m	krill (30-40mm) and salps
9	10-0	100	314	0.318	above acoustic bomb	salps and some algae and mixed krill

Moc 158 M 09 Dusk 04:49 Area C Init. 60 53.00S Init. 055 45.60W Fin. 60 54.70S Fin. 055 50.40W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	18	222	0.081	blue salp targets	icefish larvae, salps and small to medium krill
2	25-50	10	323	0.031	scattered blue targets	small krill and salps
3	50-75	2	388	0.005	blank screen	salps and small krill
4	75-100	1	346	0.003	blank screen	salps, amphipods and T. macrura
5	100-200	0	599	0.000	blank screen	4 large chaetognaths, salps and T. macrura
6	200-50	1	1432	0.001	blank screen	salps, T. macrura, amphipods
7	50-25	0	285	0.000	scattered blue targets	T. macrura and algae
8	25-10	27	459	0.059	scattered blue targets	large salps and mixed krill
9	10-0	40	363	0.110	above the acoustic bomb	algae, large salps and juvenile krill

Moc 159 M 10 Day 08:01 Area C Init. 60 52.01S Init. 055 34.55W Fin. 60 53.75S Fin. 055 41.01W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-50	5	843	0.006	light scattered blue dots	salps and juvenile krill
2	50-40-50	50	1262	0.040	dense small red/yellow at 40m	50:50 salps and krill
3	50-75	0	465	0.000	scattered krill patches below 75m	salps, T. macrura and amphipods
4	75-100	50	485	0.103	scattered krill in 75-110m	50:50 salps and krill
5	100-75	1	451	0.002	scattered green weak targets	copepods and T. macrura
6	75-50	6	606	0.010	scattered green weak targets	copepods
7	50-25	0	450	0.000	scattered blue targets	small salps, amphipods and T. macrura
8	25-10	1	263	0.004	small red and scattered blue	salps
9	10-0	1	343	0.003	above the acoustic bomb	algae, salps and amphipods

Moc 160 M 11 Day 12:20 Area C Init. 60 46.51S Init. 055 37.20W Fin. 60 47.06S Fin. 055 39.65W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	9	385	0.023	blue/green/yellow/red targets	krill (40 and 50 mm), T. macrura and amphipods
2	25-50	10	357	0.028	not as dense as upper 25m, more blue than green	krill (40 and 50 mm), T. macrura and amphipods
3	25-31	6	277	0.022	small green and red targets	krill (40 and 50 mm), T. macrura and amphipods
4	31-0-75	30	879	0.034	ship lost power	krill (40 and 50 mm), T. macrura and amphipods
5	75-50	6	425	0.014	green/blue targets	krill (40 and 50mm), T. macrura, amph. and poly.
6	50-30	8	144	0.056	blue scattered targets	krill (40 and 50mm), amphipods
7	30-30	15	335	0.045	solid blue dark	krill (40 and 50mm), amphipods
8	30-10	5	348	0.014	weak blue and green target	krill (40 and 50mm), T. macrura
9	10-0	0	289	0.000	above the acoustic bomb	algae and amphipods

Table 5.1 : MOCNESS data summary for AMLR 1992 stations.
Note: depths shown are target depths, not the actual depth sampled.
Each depth must be corrected for offset of acoustic bomb and pressure monitor

Moc 161 | M 12 | Day | 23:14 | Area D | Init. 61 05.56S | Init. 056 09.80W | Fin. 61 06.99S | Fin. 056 06.80W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	6	340	0.018	small discrete targets, little background red/blue	krill 50mm, T. macrura and amphipods
2	25-50	3	414	0.007	scattered blue targets, 40-50m blue/red/yellow	krill 50mm, T. macrura, amphipods and polychaetes
3	50-75	1	375	0.003	few individual blue dots	krill 50mm, T. macrura and amphipods
4	75-100	1	283	0.004	gr/y at 80-85m, net 80m - blue 75-80m, net 97m	T. macrura, amphipods
5	100-150-100	0	675	0.000	no target, thin blue layer at 70-80m	T. macrura, amphipods
6	100-65	0	404	0.000	no target	T. macrura
7	65-65	0	199	0.000	blue at 55-70m, thinning at 65m/very little	
8	65-7	0	727	0.000	no target	krill 50mm, algae, T. macrura and amphipods
9	7-0	0	285	0.000	above the acoustic bomb	algae, amphipods and T. macrura

Moc 162 | M 13 | Night | 03:46 | Area D | Init. 61 05.71S | Init. 056 06.70W | Fin. 61 06.35S | Fin. 056 05.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	50	377	0.133	scattered blue dots	50:50 salps and krill (30-50mm)
2	25-50	1	296	0.003	dense blue dots	salps
3	50-75	6	232	0.026	dense blue targets	T. macrura and mixed krill
4	75-100	5	347	0.014	no targets	salps, T. macrura and mixed krill
5	100-200-100	20	1616	0.012	no targets	T. macrura
6	100-75	6	325	0.018	no targets	T. macrura and copepods and mixed krill
7	75-50	100	560	0.179	scattered blue/blue,green,yellow target	salps and krill (30-50mm)
8	50-25	100	199	0.503	dense green blue cluster	salps and krill (30-50mm)
9	25-0	500	723	0.692	blue/green cluster	krill 30-50mm, algae and salps

Moc 163 | M 14 | Dawn | 05:58 | Area D | Init. 61 07.73S | Init. 056 05.65W | Fin. 61 09.47S | Fin. 056 03.94W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-30	300	334	0.898	dense red/green small cluster	
2	30-32	20	557	0.036	dense blue cluster	50:50 salps and krill
3	32-37	100	278	0.360	dense blue cluster	salps and mixed krill
4	37-37	5	154	0.032	scattered blue/ inbetween 2 blue swarms	small zooplankton
5	37-37	100	194	0.515	dense blue cluster	mixed krill
6	37-36	50	223	0.224	dense blue cluster	mixed krill
7	36-37	50	225	0.222	blue thinning out, moving up	mixed krill
8	37-31	50	244	0.205	dense blue cluster	algae and mixed krill
9	31-30	100	385	0.260	dense blue cluster	algae and mixed krill

Moc 164 | M 15 | Day | 08:36 | Area D | Init. 61 08.33S | Init. 056 05.06W | Fin. 61 10.41S | Fin. 056 02.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-25	3	505	0.006	scattered blue targets	T. macrura and amphipods
2	25-50	0	243	0.000	above dense red target	small sample, mixed zooplankton
3	50-75	0	218	0.000	scattered blue	small sample, mixed zooplankton
4	75-100	0	502	0.000	scattered blue	copepods
5	100-150-100	0	607	0.000	no target	salps
6	100-75	0	336	0.000	scattered blue/krill target at 40m when at 85m	small sample, mixed zooplankton
7	75-50	0	324	0.000	weak scattered blue	small sample, mixed zooplankton
8	50-25	1	404	0.002	weak scattered blue	algae, amphipods and salps
9	25-0	0	376	0.000	weak scattered blue	algae

Moc 165 | M 16 | Day | 15:05 | Area D | Init. 61 00.77S | Init. 056 16.00W | Fin. 61 01.70S | Fin. 056 16.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-33	2	902	0.002		T. macrura and amphipods
2	33-33	6	167	0.036	green/red/yellow target	amphipods
3	33-34	11	162	0.068	green/red/yellow target	salps, amphipods and 30-50mm krill
4	34-50	7	188	0.037	scattered blue	T. macrura and amphipods
5	50-63	15	132	0.114	green target	50mm krill, amphipods and polychaetes
6	63-54	15	153	0.098	green target	50mm krill, amphipods and polychaetes
7	54-35	5	136	0.037	top of green target	T. macrura and amphipods
8	35-22	1	157	0.006	transition between green and red target	T. macrura and amphipods
9	22-22	17	162	0.105	red/yellow target	amphipods

Moc 166 | M 17 | Day | 17:02 | Area D | Init. 60 59.84S | Init. 056 13.61W | Fin. 61 01.35S | Fin. 056 14.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-32	45	329	0.137	first net to red top layer	krill 30-50mm
2	32-34	40	308	0.130	in the red top layer	krill 40-50mm, amphipods and T. macrura
3	34-34	29	308	0.094	in the red top layer	salps, krill 40-50mm and amphipods
4	34-29	25	304	0.082	in the red top layer	krill 40-50mm
5	29-58	15	129	0.116	transition to green bottom layer	krill 40-50mm
6	58-73	23	417	0.055	in green bottom layer	krill, amphipods and macrura
7	73-67	16	364	0.044	in green bottom layer	krill
8	67-74	17	325	0.052	in green bottom layer	krill
9	74-0	80	621	0.129	oblique to surface	mixed krill, some females with eggs

Table 5.1 : MOCNESS data summary for AMLR 1992 stations.
Note: depths shown are target depths, not the actual depth sampled.
Each depth must be corrected for offset of acoustic bomb and pressure monitor

Note: net response unit rotated so nets 5 to 9 did not show any response

Moc 167 M 18 Day 19:26 Area D Init. 60 58.87S Init. 056 08.60W Fin. 61 00.47S Fin. 056 08.00W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-35	1	300	0.003	upper 25m blank, red/yellow/green layer to 35-45m	
2	35-30	50	334	0.150	red/yellow/green layer started to thin	mixed krill 30-50m
3	30-25	25	393	0.064	dense red layer at 25m	krill 30-40mm
4	25-30	25	605	0.041	red and blue target thinning then blank screen	krill 30-40mm
5	n/a	n/a	n/a	ERR	scattered red/blue/green targets	
6	n/a	n/a	n/a	ERR		
7	n/a	n/a	n/a	ERR		
8	n/a	n/a	n/a	ERR		
9	n/a	n/a	n/a	ERR		

Moc 168 M 19 Dusk 23:08 Area D Init. 60 58.12S Init. 056 07.00W Fin. 61 00.18S Fin. 056 06.70W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-55	4	425	0.009	0-25m scattered blue targets, 25-50m denser	krill 40mm, T. macrura and amphipods
2	55-60	72	338	0.213	red/green/yellow layer fading and returning	krill 30-40mm, T. macrura and amphipods
3	60-55	30	374	0.080	red/green/yellow layer intensifying	krill and lots of T. macrura
4	55-55	64	475	0.135	red/green/yellow layer fading and returning	krill 30-50mm, T. macrura, amphipods and polychaetes
5	55-75	67	514	0.130	green target layer	krill 30-50mm, T. macrura and amphipods
6	75-50	33	427	0.077	blue/green target layer	krill and T. macrura
7	50-70	41	593	0.069	blue/green target then blank then returning	krill 30-50mm and T. macrura
8	70-70	83	449	0.185	red/yellow/green/blue layer fading and returning	krill 30-55mm, T. macrura and amphipods
9	70-0	34	1005	0.034	patchy blue/yellow/red and green targets from 80-30m	krill 30-50mm, T. macrura, amphipods and polychaetes

Moc 169 M 20 Night 01:23 Area D Init. 60 58.16S Init. 056 07.32W Fin. 61 00.15S Fin. 056 08.72W

Net	Depth	# krill	Flow	Ind/m3	Acoustic Description	Sample Description
1	0-15	20	292	0.068	strong red target in the upper 25m	krill mixed sizes and amphipods
2	15-15	65	300	0.217	strong red target 0-25m fading/returning, scattered blue	krill 20-50mm
3	15-20	300	320	0.938	strong red target 0-25m fading/returning, scattered blue	krill mixed sizes
4	20-15	200	607	0.329	strong red target 0-25m fading/returning, scattered blue	krill
5	15-10	500	623	0.803	strong red target 0-25m fading/returning, scattered blue	krill
6	10-10	1000	409	2.445	red target fading at 10m	krill 30-40mm
7	10-20	1500	558	2.688	patchy red target intensifying	krill 30-40mm
8	20-15	500	811	0.617	scattered blue targets below top red layer	krill 40-50mm and salps
9	15-0	1000	516	1.938	above top layer	krill 30-50mm

6. Marine mammal and seabird observations, Dec.13 through Mar.17; submitted by Tim Cole, College of the Atlantic.

6.1 Objectives: The primary objective was to collect photographs of whales for individual identification. Photo-identification of individual humpbacks was given highest priority. Secondary objectives were to quantify the distribution and abundance of marine birds and mammals. Tertiary objectives were to relate the distribution of marine birds and mammals to environmental parameters, and log incidental sightings of marine turtles.

6.2 Accomplishments: Strip-transect surveys were conducted during daylight hours when visibility was >1km and the ship's speed was >10.6km/hr. All seabirds seen in a 90° arc from dead ahead to the beam and within 300m of the ship were counted. Marine mammal records were divided into animals seen within the 90° (but no cut-off distance), and those seen outside of this arc, seen opportunistically, or seen by one of the crew members. The latter were considered "off effort" sightings. Interviews with casual observers helped identify animals to lowest possible taxa. Photographs of the ventral fluke patterns of humpback whales were taken with Olympus and Nikon cameras equipped with 300mm lenses and 200 to 400ASA film (the 400ASA film was "pushed" to 1000 for low light conditions). The *Surveyor* and a Zodiac were used as platforms for photographing. Additional photographs and video footage were solicited from scientists and crew.

During the *Surveyor's* transit between Seattle and Punta Arenas (Dec.13 to Jan.12; 25 days at sea), 120.5 hours of observation were completed. Environmental data were collected by the ship's officers for each half-hour of observation. Fifty-four seabird species, 14 cetacean species, and 3 pinniped species were seen during this transit. Three incidental sightings of hard-shelled sea turtles were recorded. On Leg I (Jan.15 to Feb.13; 30 days at sea), 55.2 hours of observation were conducted. Twenty-eight seabird species, 8 cetacean species, and one pinniped species were observed. Photographs were taken of the ventral fluke patterns of four different humpback whales, and video footage of a fifth was collected. On Leg II (Feb.18 to Mar.18; 30 days at sea), 41.2 hours of observation were completed. Twenty-six seabird species, five cetacean species, and one pinniped species were recorded. No photographs of whales were taken for individual identification during this leg. Environmental data for both Leg I and Leg II were collected by a weather/navigation system installed on board the *Surveyor* at Punta Arenas.

In the study area around Elephant Island, 762km^2 of water surface were scrutinized over 39.9 hours in Leg I, and 546.3km^2 were covered in 32.8 hours during Leg II.

6.3 Tentative Conclusions: The numbers of individuals of each species of seabird and marine mammal were totaled for each geographical zone. These zones included: I, North Pacific Ocean (>20°N); II, Tropical Pacific (<20°N and <20°S); III, South Pacific (>20° S); IV, Chilean Inside Passage; V, Tierra del Fuego Shelf; VI, Drake Passage; and VII, Antarctica (>60° S). Values are presented in Tables 6.1 and 6.4.

Seabird abundance was fairly high during the transit in the north Pacific, but dropped substantially for the tropics. There was little increase through south Pacific waters. Abundance increased again on the inside passage along the southern Chilean coast. Only a few grey-headed albatross were seen during the inside passage in comparison to 1988. No Parkinson's or Westland petrels were seen; however, black-browed albatross were fairly abundant (see Breese, AMLR 1988/89).

The highest concentration of seabirds was seen off southeastern Terra del Fuego at the beginning of Leg I. Both thin-billed and antarctic prions were seen in flocks of up to 2000. Sooty shearwaters, terns, black-browed albatross, cape petrels, and southern giant petrels were also numerous. Ten little shearwaters were seen in this area. They may have been wandering with the more migratory sooty shearwater, but additional sightings in this area may eventually confirm Harrison's (1987) suspicion that this area is within the little shearwaters' range. On Leg II, only Wilson's storm-petrels were abundant along the Terra del Fuego shelf, especially at the shelf-break. A few greater shearwaters were present near the mouth of the Magellan Strait; none had been seen on the previous leg. Additionally, what appeared to be Manx shearwaters were also observed, considerably south of their austral summer range.

In the Drake Passage, storm-petrels, prions, blue petrels, and black-browed albatross were the prominent species. Wilson's storm-petrel numbers quadrupled on Leg II, while the opposite was true of the other species, including the sympatric black-bellied storm-petrel.

Below 60°S, Wilson's storm-petrels were considerably more abundant on Leg II than Leg I. Black-bellied storm-petrels showed a modest increase on Leg II, as did southern giant petrels. The fledging of penguin chicks may play a role in the giant petrels' increased presence offshore. Blue petrels, often seen in the company of prions during Leg I, were largely absent for Leg II. Prions, meanwhile, were equally abundant on both legs. Cape petrel and antarctic fulmar density changed dramatically and inversely to each other between legs. Cape petrels had the highest recorded density of any species in Leg I, but dropped significantly in Leg II. Fulmar density in Leg I ranked third, but in Leg II was nearly double the cape petrels' high of the previous leg. Both black-browed and grey-headed albatross numbers were higher in Leg II. In terms of biomass, black-browed albatrosses ranked third overall. The density and biomass of the nine most frequently seen species are presented in Table 6.2. Body weights for biomass estimates are adapted from Ribic and Ainley (1989), and for blue petrels from Croxall and Gaston (in press). An adult wandering albatross (stage 7) with blue and red lines on the left side of its neck and red on its right was seen about 9km north of Elephant Island on February 8.

The sighting data of chinstrap penguins at sea were divided into 5km distance increments and three directional sectors originating from Seal Island. The sectors included due east of Seal Island to due north, north to west, and west to south. The total numbers of penguins seen in each resulting block were divided by the area of coverage within each block. The results are presented in Table 6.3. The greatest concentration of penguins occurred between 15km and 20km from the island. This corresponds to the normal foraging range of radio-tagged animals (Croll, personal communication). The increase in penguin numbers beyond 30km in the west-to-south sector may be the influence of Elephant Island animals.

Large numbers of fin whales and pilot whales were present off the southeastern tip of Tierra del Fuego during Leg I. However, no whales were present in this area during Leg II. Several fin whales were seen during each crossing of Drake Passage, but none were seen south of 60°S during Leg I. On Leg II, 17 fin whales were seen together on the shelf-break north of Elephant Island, coincident with an oceanographic front. Another 13 fin whales were seen 5km northeast of Gibbs Island. Several other lone fin whales were seen within the large-area survey during Leg II. A similar southerly shift in fin whales late in the austral summer was also noted by Hamilton and Robertson in 1990 (AMLR 1989/1990).

Two humpbacks and a minke whale were seen in the company of roughly 60 pilot whales about 110km northwest of Elephant Island on January 21. Hydroacoustic recordings of the area showed only a thin layer of krill near the surface. Predatory squid, undetectable with the sonar system on board the ship, may have been the cause of the krills' vertical distribution and the cetaceans' residency. The remainder of the humpback sightings occurred along the southern coast of King George Island, including a group of five whales seen together inside Maxwell Bay. No humpbacks were spotted during Leg II.

Minke whales were the most frequently sighted cetacean on the shelf near Elephant Island. They often approached the ship while it was at anchor or on a station. On two such occasions, the whales were apparently feeding, with their upper mandibles held above the surface. Another minke had seven or more of what looked to be cookie-cutter shark bites on its right flank. Perhaps this is notable for minke whale migration or cookie-cutter shark distribution.

Odontocete species seen in the study area included a sperm whale, a group of five beaked whales, pilot whales, and hourglass dolphins. The sperm whale was seen only 13km northeast of Seal Island, in 700m of water. The beaked whales were seen on the shelf-break to the northwest of Seal Island. They may have been Tasman beaked whales. Four separate sightings of pilot whale schools were recorded, three occurring in Leg I. All the pilot whales seen in the study area and off Terra del Fuego had prominent white pigmentation patches behind the dorsal fin and post-ocular blazes. Three separate sightings of hourglass dolphins were made below 60°S. One group of four was observed resting for 15 minutes at the surface, in 3912m of water.

6.4 Disposition of data: Census data sheets and computer data files will be kept by Tim Cole, and a copy of the computer files will be given to David Ainley of the Point Reyes Bird Observatory in Stinson Beach, CA. The marine mammal data files will be submitted to the *Surveyor's* Marine Mammal Log. Additional copies will be kept by Tim Cole and Allied Whale, in Bar Harbor, ME.

6.5 Problems and suggestions: Observations of surface activities is an important addition to the study of the antarctic ecosystem; therefore, positions for several observers should be provided to allow continuous monitoring during favorable conditions. In addition, whale studies should be given more attention in the form of ship time and funding. Cetaceans are of international concern and are a krill predator. The *Surveyor* provides one of the few opportunities for cetacean research in the antarctic region.

6.6 Literature Cited:

Breese, D. 1989. Underway seabird and marine mammal observations, Leg I. AMLR Cruise Report, 1988/89.

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Harrison, P. 1987. A Field Guide to Seabirds of the World. The Stephen Greene Press. Massachusetts. 317 pp.

Ribic, C.A., and D.G. Ainley. 1989. Constancy of seabird assemblages: an exploratory look. *Biol. Ocean.* 6:175-202.

Croxall, J.P., and A.J.Gaston. Patterns of reproduction in high-latitude northern- and southern-hemisphere seabirds. In press.

TABLE 6.1 Note: Legend on second page.

ZONE[1]	I	II	III	IV	V(I)[2]	V(II)	VI(I)	VI(II)	VII(I)	VII(II)
Hours of effort	30.5	51	27.5	13	5.5	3.0	6.5	4.8	41.7	34.4
Total # birds/hr effort	68.4	5.5	12.6	53.9	448.7	111	32.3	44.2	74.5	96.5
Number of species[3]	24	21	21	21	15	10	9	7	17	22
Alcid spp.	16									
Ashy storm-petrel	3									
Black-footed albatross	2									
Black-legged kittiwake	34									
Cassin's auklet	991									
California gull	47									
Common murre	1									
Herring gull	50									
Laysan albatross	1									
Northern fulmar	172									
Pacific loon	1									
Pomarine skua	4									
Ring-billed gull	6									
Rhinocerus auklet	40									
Red-necked phalarope	502									
Western gull	8									
Xantus murrelet	2									
Band-rumped storm-petrel	3	44								
Buller's shearwater	1	1								
Black storm-petrel	1	3								
Fregata spp.	3	1								
Leach's storm-petrel	65	101								
Pink-footed shearwater	53	8								
Red-billed tropicbird	3	3	10							
Larus spp.	33	3	2							
Red phalarope	2	7		1						
Sooty shearwater	39		1	246	218	6	1			
Storm-petrel spp.	4	11							5	6
Gould's petrel		14								
Laughing gull		1								
Newell's shearwater		2								
Red-footed booby		26								
Red-tailed tropicbird		1								
Townsend's shearwater		1								
White-throated storm-petrel		1								
Arctic Skua		1	2							
Cook's Petrel		1	5							
Hawaiian petrel		1	2							
Kermadec petrel		1	8							
Masked booby		28	17							
Madeiran storm-petrel		6	1							
White-bellied storm-petrel		12	14							
Catharacta spp.		4		7	8					
Gadfly petrel spp.			2							
Salvin's albatross			2							
Sooty tern			1							
Swallow-tailed gull			45							

ZONE	I	II	III	IV	V(I)	V(II)	VI(I)	VI(II)	VII(I)	VI(II)
Stejneger's petrel			18							
White-necked petrel			127	1						
Kelp gull			3	12						
Albatross spp.			1	2	1				1	3
South polar skua			1	5					5	
Black-browed albatross			12	79	134	30	13	5	87	79
Southern giant petrel			4	15	45	5	2		22	52
White-chinned petrel			50	5	2	6	2	3	5	4
Wilson's storm-petrel			9	5	205	260	38	156	173	318
Prion spp.			1		1411	1	61	24	125	114
Penguin spp.			2		1	1			276	2
Grey-headed albatross			5				1		10	17
Brown-hooded gull				102						
Buller's albatross				1						
Magellanic penguin				125	42					
Puffinus spp.				1	7					
Royal albatross				2	1					
Chilean skua				24	1					
Pelecanoides spp.				3	2	3	1	3	1	
Sterna spp.				19	220				1	4
Antarctic tern				27	1				8	4
Imperial commorant				14					4	1
Antarctic skua				5					1	2
Arctic tern					6	1				
Little shearwater					10					
Manx shearwater						13				
Greater shearwater						3				
Procellarid spp.						1				
Wandering albatross					1		1			1
Gentoo penguin					25			5	2	
Blue petrel					6		22		48	3
Cape petrel					121		10		1037	232
Black-bellied storm-petrel							58	16	246	314
Antarctic petrel									1	
Antarctic fulmar									164	1426
Chinstrap penguin									880	697
Light-mantled sooty albatross									3	5
Soft-plumaged petrel										1
Snow petrel										3
White-headed petrel										1

[1] I = North Pacific Ocean (>20°N); II = Tropical Pacific (<20°N and <20°S); III = South Pacific (>20°S); IV = Chilean Inside Passage; V = Tierra del Fuego Shelf; VI = Drake Passage; VII = Antarctica (>60°S).
[2] Roman numeral in parentheses indicates Leg I or Leg II.
[3] Species names after Harrison (1987).

TABLE 6.2

Species	Body weight (kg)	No./km^2 Leg I	kg/km^2 Leg I	No./km^2 Leg II	kg/km^2 Leg II
Antarctic fulmar	0.78	0.22	0.17	2.61	2.04
Cape petrel	0.45	1.36	0.61	0.42	0.19
Black-bellied storm-petrel	0.06	0.32	0.02	0.57	0.03
Wilson's storm-petrel	0.03	0.21	0.01	0.58	0.02
Prion spp.	0.16	0.16	0.03	0.21	0.03
Black-browed albatross	3.02	0.11	0.34	0.14	0.44
Southern giant petrel	4.4	0.03	0.12	0.1	0.42
Blue petrel	0.2	0.06	0.01	0.01	0.001
Grey-headed albatross	3.6	0.01	0.05	0.03	0.11

TABLE 6.3

km from Seal I.	10	15	20	25	30	35	40	45	$\bar{X}$
No. Penguins (E-N)	32	167	0	0	0	19	0	1	
Coverage (km^2) (E-N)	5.6	10.6	0	0	0	6.1	3.8	2.5	
No. Penguins/km^2 (E-N)	5.7	15.7	0	0	0	3.1	0	0.4	7.7
No. Penguins (N-W)	14	85	125	25	12	0	13	23	
Coverage (km^2) (N-W)	2.8	3.7	5.6	5.1	3.2	2.9	5.1	7.6	
No. Penguins/km^2 (N-W)	5	23.1	22.5	4.9	3.7	0	2.6	3	8.3
No. Penguins (W-S)	0	86	109	0	41	36	63	93	
Coverage (km^2) (W-S)	0	5.6	4.1	0	8.8	2	6.6	9.3	
No. Penguins/km^2 (W-S)	0	15.3	26.3	0	4.6	17.7	9.5	9	11.7
$\bar{X}$ No. Penguins/km^2	5.5	17	24.1	4.9	4.4	5	4.9	6	

TABLE 6.4 Note: Shaded rows represent off effort sightings.

ZONE[1]	I	II	III	IV	V(I)[2]	V(II)	VI(I)	VI(II)	VII(I)	VII(II)
Hours of effort	30.5	51	27.5	13	5.5	3.0	6.5	4.8	41.7	34.4
# sightings on effort[3]	28	6	3	1	6	0	0	2	7	4
# species (on and off effort)	7	6	3	4	4	0	3	1	8	5
Blue whale		1								
Fin whale		2			3			1		
**					15(5)[a]		9(4)	5(3)		34(9)
Bryde's whale			1							
**		1								
Minke whale									1	
**							1		4(4)	8(5)
Humpback whale	1								2	
**	4(2)			1					12(4)	
Mysticete spp.	1		1					1	1	
**							1		3(3)	1
Sperm whale			1						2(2)[b]	
Beaked whale spp.									5[c]	
Orca										4(1)
Pilot whale	3	6			10					
**					160(3)		3		95(3)	3(1)
Dusky dolphin				3						
Pacific white-sided dolphin	30									
Hourglass dolphin										7(1)
**					14(2)				22(2)	
Peale's dolphin				30(4)						
Common dolphin	230(2)									
Risso's dolphin		40								
Striped dolphin			40							
Stenella spp.		80(2)								
**		55								
Commerson's dolphin				20(4)						
Delphinid spp.		64(2)			30					
Dall's porpoise	32(5)									
**	76(6)									
California sea lion	66(18)									
**	6(3)									
Southern sea lion				3(3)						
**				5						
Antarctic fur seal									4(4)	3(3)
**									8(3)	24(10)
Northern elephant seal	2(2)									
Pinniped spp.									1	
**									1	

[1]I = North Pacific Ocean (>20°N); II = Tropical Pacific (<20°N and <20°S); III = South Pacific (>20°S); IV = Chilean Inside Passage; V = Tierra del Fuego Shelf; VI = Drake Passage; VII = Antarctica (>60°S).
[2]Roman numerals in parentheses indicate Leg I or Leg II.
[3]One sighting can include a group individuals.
[a]First value = total number of individuals seen; value in parentheses = number of sightings.
[b]One identification only tentative.
[c]Possibly Tasman beaked whale (Tasmacetus shepherdi).

7. Census of antarctic fur seal colonies of the South Shetland Islands, 1991/92; submitted by D. A. Croll, J. L. Bengtson, National Marine Mammal Laboratory; R. Holt, Southwest Fisheries Science Center; and D. Torres-N., Instituto Antarctico Chileno.

7.1 Objectives: The CCAMLR Scientific Committee has recognized the importance of monitoring trends in the abundance of marine mammal and bird populations within the Convention area. One important area of interest for the CCAMLR Scientific Committee is the South Shetland Islands, whose colonies of land-breeding pinnipeds and seabirds are located adjacent to important commercial fishery grounds. This is also a key zone within the Antarctic Peninsula Integrated Study Region of the CCAMLR Ecosystem Monitoring Program (CEMP). Populations of pinnipeds and seabirds in the South Shetland Islands have been censused sporadically during the past several decades, with the most recent survey being carried out during the 1986/87 austral summer.

The survey undertaken during the 1991/92 austral summer had two main objectives:

(1) to count antarctic fur seals at known rookery sites, and

(2) to identify newly-established and previously unknown fur seal colonies.

7.2 Accomplishments: Surveys were conducted at Elephant, King George and Livingston Islands on 19 January 1992 and 21-25 February 1992. A Zodiac Mk5 inflatable boat was deployed from the NOAA Ship *Surveyor* or the Chilean research vessel *Alcazar* in the proximity of known and likely fur seal colonies. Initially, the coastline of study areas were surveyed for evidence of fur seals and calm places to land. Once a likely area with a safe landing had been identified, the survey party disembarked and proceeded to make counts of fur seal adult males, females, pups, and other pinnipeds, as well as estimations of penguin densities and counts of man-made debris on the beach.

These counts were made as investigators walked along the periphery of the colony. Large colonies were subdivided by natural landmarks, and a series of three counts of fur seal pups was completed at each colony or subdivision. If one of these counts differed by more than 10% from the other two, a fourth count was made. Due to time limitations and weather, a single count of fur seal pups was made at the largest colony (South Islet, Telmo Island). It should be noted that counts of fur seal females likely include some proportion of subadult males. We estimate that as many as 25% of animals counted as adult females could have been subadult males.

A total of 8 fur seal colonies in the South Shetland Islands had been identified in previous studies (Bengtson et al. 1990). Counts were made during the 1991/92 season at all of these sites: Cape Shirreff, Livingston Island; Telmo Islands, Livingston Island; Window Island, Livingston Island; Stigant Point, King George Island; Cape Lindsey, Elephant Island; Cape Valentine, Elephant Island; Seal Island and Large Leap Island (an informal name used by AMLR personnel for an island north of Seal Island). Two additional sites, where evidence of fur seal breeding had been reported earlier, were also surveyed (Start Point, Livingston Island; Desolation Island, Livingston Island). In the present survey, we report counts for all of these sites except for Cape Shirreff, which was surveyed by Chilean scientists (Table 7.1). Data for pup abundances at Seal Island (January) and Large Leap Island (9 February) were taken from the accompanying pinniped report in this volume (Goebel et al, 1992).

Marine Debris: During survey operations, an evaluation of the quantity of beached debris of human origin was recorded. Three main categories of debris were encountered: (1) plastic straps, approximately 1.5cm in width, 75cm in length (these straps are typically used in the fishing industry to seal the lids of product boxes); (2) wood; (3) oil drums; and (4) fishing floats. With the exception of plastic straps, little debris was encountered on most of the beaches surveyed. At each site, a count of plastic straps, oil barrels, and fishing floats was made, and a subjective evaluation of the wood debris was recorded (Light: 1-5 pieces; Moderate: 5-15 pieces; Heavy: more than 15 pieces) (Table 7.2). Marine debris was found to be ubiquitous, but fairly low in concentration. Plastic straps were the exception to this observation: they were found at most sites in high concentrations. Fur seals have been observed entangled in plastic straps regularly (Seal Island, South Shetland Islands, D.A. Croll, personal observation).

7.3 Preliminary Conclusions: Ideally, counts of antarctic fur seal populations should be made in late December/early January, soon after the completion of pupping. The present survey was conducted relatively late in the breeding season. As a result, these counts probably represent a minimum estimate as many pups may have died or could have been consumed by predators prior to the survey date. Regardless, with the exception of Stigant Point, King George Island, counts of pups indicate that the population of antarctic fur seals in the South Shetland region continues to increase. Although not possible in the present survey due to time limitations, it is important to conduct a thorough survey of the entire coastline of the South Shetland Islands to locate new colonies.

Table 7.1. Numbers of Antarctic fur seals, Weddell seals, and southern elephant seals present at selected sites in the South Shetland Islands, Antarctica, during the 1991/92 austral summer. Only fur seal pups were counted at Seal Island, Large Leap Island, and Cape Valentine. For comparison, the totals of fur seal pups counted during the 1986/87 austral summer at selected sites are shown (Bengtson et al., 1990*).

Location	Fur seal non-pups		Fur seal pups				Weddell seals	Elephant seals
	Male	Female	Alive	Dead	Total	86/87		
Cape Valentine	-	-	126	0	126	45	-	-
Cape Lindsey	81	188	227	0	227	203	0	0
Seal Island	-	-	300	5	305	249	-	-
Large Leap Island	-	-	258	0	258	275	-	-
Stigant Point	143	175	134	0	134	157	17	1
Desolation Island	104	0	0	0	0	1	12	12
N. Telmo Island	65	228	761	25	786	-	1	0
S. Telmo Island	117	274	1511	43	1554	-	3	1
Total Telmo Islands	182	502	2272	68	2340	1875	4	1
Window Island	173	72	372	3	375	297	0	0
Start Point	196	82	43	0	43	0	1	10

* Bengtson, J.L., L.M. Ferm, T.J. Härkönen, and B.S. Stewart. 1990. Abundance of Antarctic fur seals in the South Shetland Islands, Antarctica, during the 1986/87 austral summer. Pp. 265-270 in Antarctic Ecosystems, Ecological Change and Conservation. K. Kerry and G. Hempel (eds.). Springer-Verlag: Berlin.

Table 7.2. The occurence of man-made debris at selected Antarctic fur seal breeding colonies in the South Shetland Islands, Antarctica, during February 1992. The relative amount of wood debris (excluding natural driftwood) was categorized subjectively as light (1-5 pieces), moderate (6-15 pieces), and heavy (more than 15 pieces).

Location	Plastic straps	Wood	Oil barrel	Fishing float
Cape Lindsey	0	light	0	0
Stigant Point	11	heavy	2	2
Telmo Island	16	moderate	3	1
Window Island	0	none	0	0
Start Point	17	light	0	0
Desolation Island	8	moderate	1	2

8. CCAMLR Inspection of Russian krill fishing vessel Poytr Sgibnev; submitted by R. Holt, Southwest Fisheries Science Center; and Victor Ross, NOAA Corps.

On 26 February 1992, researchers on board NOAA Ship *Surveyor* were conducting an acoustic survey to determine the abundance and distribution of krill near Elephant Island, Antarctica (60°41'S and 055°24'W). At approximately 1300 hrs, officers observed a Russian fishing vessel approximately 3 n.mi. off *Surveyor's* port bow. The CCAMLR inspection pennant was hoisted. The Russian ship was contacted and identified itself as the Russian krill fishing vessel *Poytr Sgibnev*. The ship's captain, Vaycheslav Bulatov, was contacted and indicated that he was familiar with the CCAMLR inspection program. The U.S. CCAMLR inspector, Dr. Rennie Holt, then requested permission to board the Russian vessel to conduct a CCAMLR inspection. Captain Bulatov readily agreed and offered to send a boat to pick up Dr. Holt and another US CCAMLR Inspector, ENS Victor Ross. However, *Surveyor* was already preparing to launch its boat and at 1356 hrs, Dr. Holt and ENS Ross departed *Surveyor* to board *Poytr Sgibnev*. The boarding was completed without incident in calm seas.

Once on board *Poytr Sgibnev*, the inspectors were escorted to the captain's quarters where they were given refreshments and enjoyed very cordial discussions concerning fishing activities. ENS Ross and Captain Bulatov completed the CCAMLR inspection forms. Captain Bulatov did not have the inspection forms written in Russian; however, he apparently could read the English forms and spoke very good English. After ENS Ross completed the forms, Captain Bulatov and ENS Ross signed in the appropriate spaces, and Captain Bulatov was given the blue copy of each page of the forms. Captain Bulatov indicated that he had been fishing for krill at the South Orkneys and had just arrived in the Elephant Island area to search for krill. He showed the inspectors his log book, written in Russian, which indicated that catches had been 100% krill. The inspection team was provided a very complete tour of the ship. Numerous photographs were taken with the permission of the captain. Because the ship was searching for krill when boarded, there was no unprocessed catch to examine. However, the processing area had numerous residual krill present. The inspection team did not ask for access to the ship's hold or net storage areas.

Upon completion of the tour, the party returned to the captain's cabin and was presented with a gift of frozen fish. The inspection team then departed *Poytr Sgibnev* and returned to *Surveyor* at 1500 hrs. The inspection party was treated very well, and *Poytr Sgibnev's* officers and crew were very courteous. The captain was invited to return to *Surveyor* but declined because of his need to begin fishing operations. Upon returning to *Surveyor*, the fish presented by Captain Bulatov were identified as ocellated icefish (*Chionodraco rastrospinosus*).

In conclusion, the boarding proceeded very smoothly because of the efficiency of *Surveyor's* command. The inspection on board the *Poytr Sgibnev* was completed effectively because of the hospitality offered by Captain Bulatov and his command.

9. Polycyclic aromatic hydrocarbons around Elephant Island, Antarctica; submitted by Rebeca Dorion Guesalaga and Christian Bonert Anwandter, Servicio Hidrográfico y Oceanográfico de la Armada de Chile.

During the 1992 field season of the Antarctic Marine Living Resource (AMLR) program, another research project was conducted in the Elephant Island area. This research project was funded by the Servicio Hidrográfico y Oceanográfico de la Armada de Chile (SHOA). The objectives of this research was to establish the background concentration of specific polycyclic aromatic hydrocarbons (PAH) components in the area.

Ten samples of water were taken around Elephant Island at the beginning of Leg I. During Leg II, a time series of samples (one per hour) was conducted during the recovery of the Seal Island scientists. The content and identification of specific components of dissolved hydrocarbon will be analyzed at the laboratory of SHOA, Valparaíso, Chile.

The authors wish to thank the AMLR Program and officers and crew of the NOAA Ship *Surveyor*. We also thank Anthony Amos for providing XBTs to augment the XBT observations started during the AMLR 1990 cruise for monitoring the thermal structure in the Drake Passage. Our gratitude is extended to Margaret Lavender and Walter Helbling for their unconditional assistance in our research.

10. Activities during northbound transit; submitted by Osmund Holm-Hansen, E. Walter Helbling, William Cochlan, Scripps Institution of Oceanography; Stella Casco, Univ. Nacional de la Patagonia, Argentina; and Anthony Amos, University of Texas at Austin.

10.1 Objectives: The *Surveyor* departed Valparaiso, Chile on 28 March 1992 and arrived in San Diego on 14 April 1992. Figure 10.1 shows the trackline during this transit. The objectives of the northbound transit were to: (1) conduct underway observations of marine mammals; (2) conduct underway observations of seabirds; (3) conduct bacterioplankton research; (4) conduct physical oceanographic and meteorological measurements; and (5) study the effects of solar ultraviolet radiation on photosynthetic rates of phytoplankton.

10.2 Accomplishments:

(1) Underway Marine Mammal Observations; submitted by Tim Cole, College of the Atlantic.

The observation post on the flying bridge was occupied from sunrise to sunset each day at sea. Marine mammal sightings included: schools of spotted, spinner, striped, common, and bottlenose dolphins; melon-headed and pilot whales; and sei, brydes, and blue whales. Southern sea lions were numerous along the Peruvian coast. A likely sighting of a Juan Fernandez fur seal occurred off the coast of northern Chile. The observed distribution of marine mammals will be examined in relation to environmental parameters such as sea surface temperature, water depth, and distance from the continental shelf break.

(2) Marine Ornithology; submitted by D. Ainley and L. Spear, Point Reyes Bird Observatory.

The observation post on the flying bridge was occupied from sunrise to sunset each day at sea. Our goal was to augment a data set collected during EPOCS cruises offshore of South and Central America, 1983-1991. We sought to collect data, in particular, from over the Peruvian continental shelf. The marine avifauna of the Peru Current is not well known. In fact, it has never been quantified on the basis of ship board data, although the Peruvian "guano birds" have been of great commercial value for centuries and a number of publications consider the breeding biology of this important guano-producing species. During EPOCS, we have been able to gather a great deal of data in this area but only seaward of the continental shelf.

We censused seabirds and marine mammals during all daylight hours when the ship was underway using the methods of Tasker et al. (1984). Approximately 4600km of ship trackline were censused, including about 1000km in the Peru Current. Results will be analyzed according to the strip-transect methods of Burhnam et al. (1980) to derive densities and biomass (per km^2). We will request continuous chlorophyll data collected by the oceanography group in order to relate bird density to variability in ocean production. Variability in seabird species composition and abundance will be related to that of the ocean environment.

We found that bird distribution off Peru fit the classic pattern of biotic production during El Niño, i.e. concentrated close to shore. The pattern differed from that observed during the 1990 AMLR cruise, when bird biomass was concentrated over the continental slope. Bird distribution also fit the present latitudinal pattern of fish availability of northern Chile and southern Peru. Farther north (central Peru to the California Current), bird biomass was unusually low, which was likely also a result of El Niño conditions. Besides these general patterns, we were able to identify aspects of the movements of several poorly-known seabirds in the South Pacific, including several species that breed in the australasian region of the subantarctic but winter in the Peru Current.

(3) Bacterioplankton research; submitted W. P. Cochlan, Scripps Institution of Oceanography.

This research project focused on the heterotrophic responses of natural bacterial assemblages of surface waters to solar radiation. Radioisotope techniques, based on the incorporation of tritiated leucine and thymidine into bacterial protein and genetic material (DNA), respectively, were used to measure bacterioplankton production under a variety of visible and ultraviolet radiation (UVR) regimes. Except for a limited study on the effects of UVR on the surface-film microlayer flora off coastal France, these are the first experiments to study the potential effects of UVR on heterotrophic productivity in the open ocean. Complementary samples for the enumeration of bacteria and viruses throughout the water column were also collected and preserved at selected tropical stations and for all surface experiments. Ancillary experiments to elucidate diurnal (day/night) periodicity of bacterial activity and the potential toxicity of polyethylene bags (routinely employed in chemical and biological oceanography) to heterotrophic bacteria were also conducted.

(4) Physical Oceanographic and Meteorological Measurements; submitted by A. F. Amos.

This component of the shipboard work had three major objectives: (1) To obtain high-quality measurements of temperature and conductivity in surface waters and in the upper water column (surface to 750m), and to complement these physical data with simultaneously acquired profiles of optical and biological data; (2) To continuously record meteorological data and incident solar radiation; and (3) To make all of the above data available in real-time to the other scientific groups. In addition, I made observations and a video record of marine birds, mammals and floating debris during all daylight hours. These observations will be correlated to the continuous underway meteorological and environmental data. The following instrumentation was used to obtain the above data:

(a) A CTD/Rosette (with eleven 10-liter Niskin bottles) with a variety of sensors was deployed at 15 stations (Table 10.1). The sensors were: (1) pressure (for depth), (2) temperature, (3) conductivity (for salinity), (4) beam attenuation coefficients (transmissometer), (5) solar irradiance, (6) *in vivo* chlorophyll-a fluorescence, and (7) dissolved oxygen.

All data were displayed in real-time and stored on 44 MByte Bernoulli disks.

(b) The ship's clean water intake line was used to record beam attenuation coefficients and *in vivo* chl-a fluorescence in surface waters. In addition, a thermosalinograph at the intake of the sea water system recorded surface temperature (SST) and conductivity, from which salinity was calculated.

(c) Meteorological sensors, which were mounted either on a platform above the flying bridge or on the ship's superstructure, included: (1) PAR Visible solar radiation (400 to 700nm), (2) TUVR total ultraviolet radiation (295-385nm), (3) PYRO visible and infrared solar radiation, (4) apparent wind speed, (5) apparent wind direction, (6) air temperature, (7) relative humidity, and (8) barometric pressure.

From these inputs, true wind speed and direction were calculated, as was the net thermal difference between atmosphere and sea. These data were recorded at one-minute intervals on the ship's LAN network and files were transferred to disk at midnight (UTC) each day. Programs were developed or refined to display the data in real-time, to allow comments to be added to the record interactively, and to plot the data and cruise track (on a multi-pen plotter) in real-time. At the end of each day, the following were provided to each of the scientific groups: a graphic output of the environmental data, the cruise track and the scientific activities, a daily log, and the daily summary. Various files of data pertinent to each program were provided to the principal investigators.

(5) Effects of solar ultraviolet radiation (UVR) on photosynthetic rates of phytoplankton; submitted by W. Helbling, O. Holm-Hansen, Scripps Institution of Oceanography; and S. Casco, Univ. Nacional de la Patagonia, Argentina

The formation of the ozone hole over Antarctica in recent years has led to much concern regarding what impact the increased solar UVR will have on the marine ecosystem. Within the past year, NASA scientists have also documented a decline in stratospheric ozone in the northern hemisphere, suggesting that the biota in the northern hemisphere will also be subjected to increasing stress from UVR. During the past three years, we have studied the effects of UVR on antarctic phytoplankton. We have found that UV-B (280-320nm), which is the only portion of solar UVR that is increased by lower ozone concentrations in the stratosphere, inhibits photosynthetic rates to about the same extent as does UV-A (320-400nm). However, during our work on the northbound transit of the AMLR cruise from Valparaiso to San Diego last year, we did not detect any significant effect of UVR on tropical phytoplankton. As this was unexpected, our major objective this year was to confirm last year's findings, and to obtain better spectral UV irradiance data, both incident upon the ocean and also with depth in the water column. Our work on board ship included the following:

(a) Water samples were taken from the Niskin bottles and incubated on the helopad in water baths with flowing sea water for temperature control. Samples were in quartz glass vessels which had various portions of the UVR removed by appropriate sharp cut-off filters. The rate of photosynthesis in these samples was determined with standard radiocarbon techniques.

(b) During all incubations, we monitored incident solar UVR with a 5-channel (305, 320, 340, 380, and 400-700nm) spectroradiometer, which was mounted on the helopad. Spectral data from all channels were recorded in our computer once per minute throughout the cruise.

(c) Chlorophyll-a was measured in all water samples from the CTD/rosette casts, in addition to several discrete samples from the ship's clean water intake each day. These latter samples were done primarily to calibrate the *in vivo* chl-a fluorescence data so that surface chl-a values could be calculated for the entire cruise.

(d) Water samples were taken from four depths from each CTD/rosette cast for later analysis (at SIO) of inorganic nutrients, photosynthetic pigments by HPLC techniques, and species composition of the phytoplankton.

Most of our radiocarbon samples will be processed in our laboratory at SIO. A limited number of samples were processed on board ship, and preliminary measurements were made of the amount of radiocarbon incorporated into the phytoplankton. These preliminary data suggest that our results will support our conclusion from last year that tropical phytoplankton are physiologically adapted so that unattenuated solar UVR has little or no effect on photosynthetic rates.

10.3 Disposition of Data: All data collected during the cruise will remain with the investigator in charge of the work. Individuals interested in acquiring any of the data should contact the investigator directly. It should be noted that all oceanographic and meteorological data recorded by A. Amos during the cruise were made available to all scientific personnel on board ship on a daily basis. The groups studying marine mammal and bird distribution and abundance will make extensive use of these data sets in order to relate their observations to oceanographic conditions and to phytoplankton abundance.

10.4 Problems and Suggestions:

(1) The use of the after-part of the chart room for the CTD/Meteorological instrument equipment worked out well. Some suggested improvements: (a) Replace the Everex 386 computer; (b) Provide direct inputs (RS232) for the weather logging computer from the thermosalinograph, Weatherpak, and GPS (rather than going through the ship's logging computer and the network); (c) Provide an HP 7475-A multi-pen plotter; (d) Install drawers and shelves in the space beneath the racks in the after-chart lab.

(2) It would aid observations immensely if the inside of the windbreak rail of the flying bridge was painted a non-glare (flat) color instead of white. This would reduce glare for observers using that vantage point for long hours. Sunglasses cannot be used effectively when binoculars are an integral part of the scanning protocol.

(3) The canvas which serves as windbreak on the port side of the railing on the flying bridge should be installed as it is on the starboard side.

10.5 Acknowledgements: All scientific personnel want to thank the Captain, officers, and crew of NOAA Ship *Surveyor* for making this cruise productive as well as enjoyable. The logistic support provided to us, and the general facilities of the ship, were excellent. The good spirit and friendship from all on the ship contributed significantly to our overall successful completion of our studies. We also want to thank all personnel in the AMLR program (Southwest Fisheries Science Center) for their help and support in making this cruise available to us.

Table 10.1 CTD Stations: Time and Location.

STA #	DATE/TIME (LOCAL)	DEPTH	LATITUDE	LONGITUDE
UV01	03-29-1992 0823	4406	28 30.402 S	72 43.308 W
UV02	03-29-1992 1306	3865	27 37.350 S	72 57.090 W
UV03	03-30-1992 0815	3673	23 29.448 S	73 46.842 W
UV04	03-31-1992 0807	4344	18 18.330 S	74 54.840 W
UV05	03-31-1992 1305	4477	17 31.212 S	75 6.198 W
UV05A	03-31-1992 1351	4489	17 30.588 S	75 6.192 W
UV06	04-01-1992 0606	145	14 59.862 S	75 39.888 W
UV07	04-02-1992 0618	677	11 19.068 S	78 18.960 W
UV08	04-03-1992 0606	76	7 8.028 S	80 16.992 W
UV09	04-03-1992 1948	153	4 46.932 S	81 26.100 W
UV10	04-03-1992 2135	1238	4 40.818 S	81 28.458 W
UV11	04-03-1992 2256	2709	4 38.058 S	81 32.580 W
UV12	04-05-1992 2133	3512	0 0.282 N	84 5.478 W
UV13	04-05-1992 0829	3150	2 2.328 N	85 10.818 W
UV14	04-05-1992 1104	2578	2 23.562 N	85 22.272 W

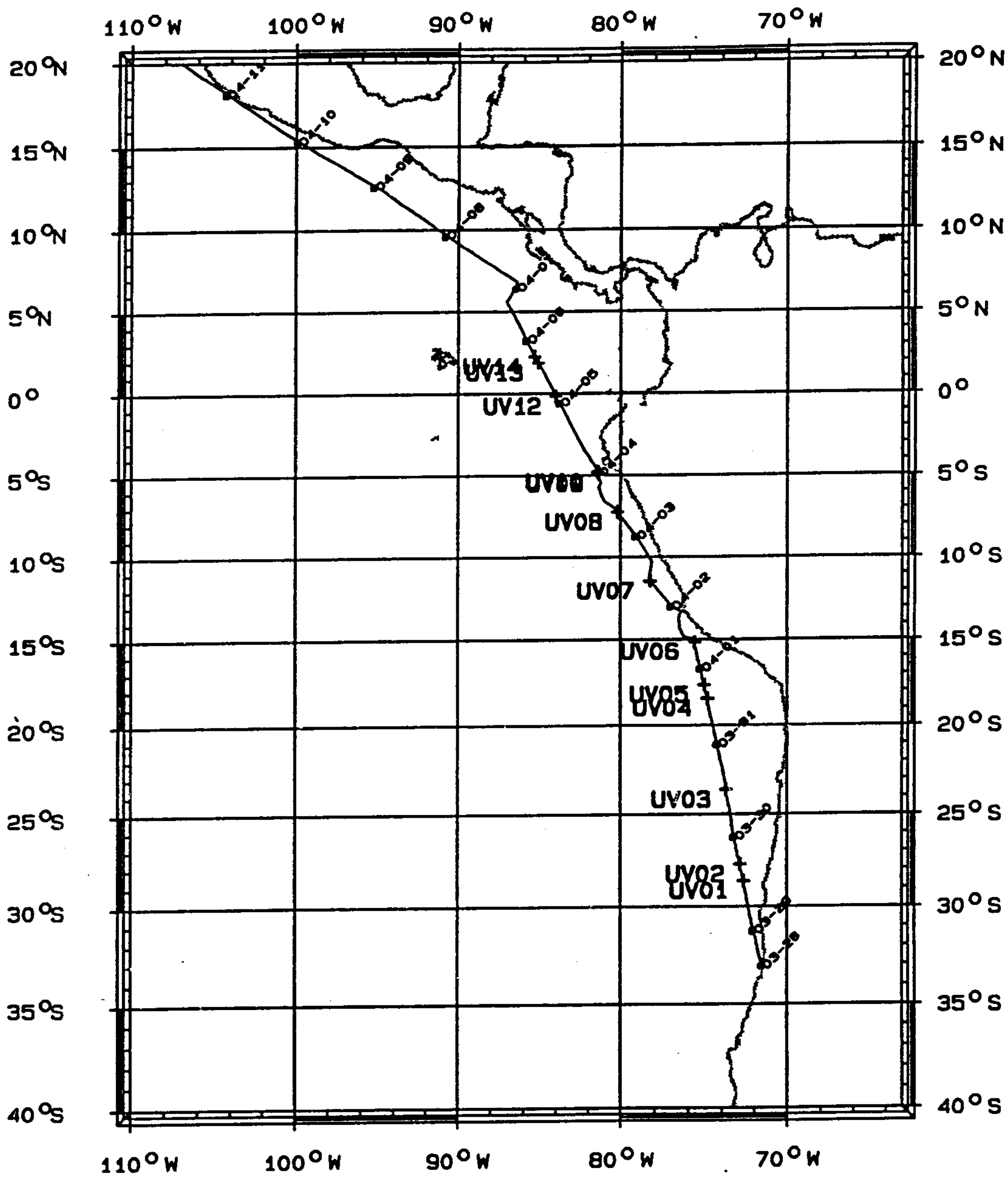


Figure 10.1 Cruise trackline for northbound transit. Solid circles indicate position of ship at 0000 (GMT) each day.

11. Seal Island Logistics and Operations During 1991/92; submitted by D.A. Croll, National Marine Mammal Laboratory.

11.1 Objectives: The AMLR Program maintains a field camp at Seal Island, South Shetland Islands, Antarctica (60°59.13'S, 55°23.13'W), in support of land-based research on marine mammals and birds. The camp is occupied during the austral summer field season, which normally runs December through early March. The main logistics objectives of the 1991/92 season were:

(1) To deploy the field team early in December on board the M/V *World Discoverer* in order to arrive at Seal Island in time to monitor fur seal pupping and penguin chick hatching,

(2) To deploy two additional field team members to assist in field studies in mid-January on board the NOAA Ship *Surveyor,*

(3) To resupply the field camp with its season's provisions which were transported from the United States on board the NOAA Ship *Surveyor,*

(4) To maintain effective communications systems on the island and to maintain daily radio contact with either Palmer Station or the NOAA Ship *Surveyor.*

(5) To repair, maintain, and improve camp facilities at the Seal Island field camp,

(6) To install and monitor an automatic weather station, and

(7) To retrograde trash and other cargo from the island and to transport the field team to Chile at the end of the season on board the NOAA Ship *Surveyor.*

11.2 Accomplishments: The four person field team departed the U.S. on 20 November and embarked on the tour ship M/V *World Discoverer* in Puerto Williams on 23 November. The field party disembarked on Seal Island on 2 December. Good weather resulted in an efficient landing at the camp beach with 2 Zodiac loads of cargo. Camp structures overwintered well, and the field party established temporary quarters in the laboratory while a seasonal tent structure was erected as housing for the remainder of the season. The early arrival of the field party allowed us to commence fur seal observations prior to the peak of pupping.

The NOAA Ship *Surveyor* arrived and disembarked two additional field party members and supplies on 18 January. Cargo operations began at 0730 and finished at 1600. Two Mark V Zodiacs were used to transport supplies ashore and retrograde trash. Landing conditions were good at the sand beach near camp, and approximately 20 Zodiac loads were brought ashore without difficulty. The assistance of ship's personnel and members of the scientific party expedited cargo operations. In addition to the persons who came ashore to help unload and carry cargo up to camp, four swimmers in dry suits were stationed to steady the Zodiacs during unloading.

On 10 February 1992, the NOAA Ship *Surveyor* returned to Seal Island and embarked two members of the field team (M.E. Goebel and C. Shin, a visiting Korean scientist) to return to Chile. The *Surveyor* returned again to Seal Island on 21 February to offload fresh supplies purchased during a port call between legs I and II. A member of the field party (D.A. Croll) embarked the *Surveyor* at this time in order to commence fur seal survey operations. Croll was returned to Seal Island to rejoin the Seal Island field party on 25 February. Good conditions on the beach at the camp on Seal Island permitted landings without difficulty on all three occasions.

Daily radio communications were maintained with Palmer Station from 2 December through 16 January prior to the arrival of the *Surveyor* in the operations area. Daily contact was maintained with the *Surveyor* from 16 January through 11 March using single side band or VHF radio when the ship was within range or INMARSAT telephone (through the ATS-3 satellite) during the ship's port call between cruise legs. In addition to these regular schedules, radio contacts were made with biologists and other personnel at Palmer Station, Anvers Island (U.S.); King SeJong Station, King George Island (Korea); Copacabana field camp, King George Island (U.S.); R/V *Alcazar* (Chile); and M/V *World Discoverer* (U.S.). Communications were also maintained with various offices in the U.S. via the ATS-3 satellite system.

Routine maintenance of camp facilities was undertaken as necessary. Obsolete and unneeded equipment was identified and removed from the island for shipment to the U.S. Wooden structures were painted and weatherproofed.

In December, an automatic weather station was installed on the aluminum weather tower present at the top of Seal Island. Wind speed, wind direction, relative humidity, temperature, and barometric pressure sensors were installed to monitor weather conditions every 10 minutes. Data were downloaded once a week by Seal Island field personnel for transport and analysis by Texas A&M University researchers. At the end of the summer field season, the station sampling rate was adjusted to once per hour. This will allow for a continuous sample of over winter weather conditions on Seal Island.

During the initial resupply of Seal Island on 18 January, trash from the early part of the season was transported to the NOAA Ship *Surveyor* for proper disposal. Additional trash and retrograde cargo was transported to the *Surveyor* each time that the ship called at Seal Island throughout the season to minimize the amount of cargo necessary to offload at the end of the season. All remaining trash was loaded onto the ship on 11 March when the camp was closed and the field team embarked the ship for transport to Chile.

11.3 Recommendations: Once again, the excellent support provided by the NOAA Ship *Surveyor* made a significant contribution to the success of the field season at Seal Island.

Cargo and small boating operations went very smoothly. The practice of providing four swimmers in dry suits to assist landings and launchings of Zodiacs has proven to be very successful, and should be continued in the future. The new procedures for deploying Zodiacs implemented by Chief Clagget greatly improved the efficiency and safety of Zodiac operations and should also be continued.

An arrival date of early December was ideal for initiating antarctic fur seal studies prior to the peak of pupping. If possible, arrival of the field team should be planned for the first week of December in future seasons as well. Such an arrival date provides good access to perinatal female fur seals, as well as an opportunity to obtain data on female fur seals' early feeding trips before their pups fall prey to leopard seals.

Daily radio communications with Palmer Station and *Surveyor* were successful throughout the season. This season we were able to contact the *Surveyor* easily, both during scheduled periods as well as during other times when the need arose. While in the operations area, the ship's constant monitoring of frequencies 4125 MHz, CH 9, and CH 16 was very helpful to operations ashore at Seal Island. Daily radio contact with the *Surveyor*, with the ship maintaining a log of such contacts, is a good arrangement that should be continued in future seasons.

12. Pinniped Research at Seal Island During 1991/92; submitted by M.E. Goebel, P. Boveng, H.D. Douglas III, and J.L. Bengtson, National Marine Mammal Laboratory.

12.1 Objectives: Several pinniped research projects were undertaken at Seal Island as part of the CCAMLR Ecosystem Monitoring Program (CEMP), a multi-national program designed to detect significant changes in key components of the Southern Ocean ecosystem and to distinguish between changes due to commercial fisheries and those due to natural causes. One of the underlying objectives of this research is to determine what factors are primarily responsible for influencing the population dynamics of antarctic pinnipeds. Current studies focus on feeding ecology, reproductive success, growth and condition, demography, and abundance, as well as the status of prey availability and other environmental conditions. During the 1991/92 field season, specific objectives of the pinniped research at Seal Island were:

(1) To monitor pup growth rates and adult female foraging of antarctic fur seals according to CCAMLR Ecosystem Monitoring Program (CEMP) protocols,

(2) To conduct directed research on pup production, female foraging behavior, diet, abundance, survival and recruitment of fur seals, and

(3) To monitor the abundance of all other pinniped species ashore.

12.2 Accomplishments:

Pup growth rates: Fur seal pups were weighed at intervals of approximately 2 weeks between 30 December 1991 and 27 February 1992 (CEMP Standard Method C.2)(Table 12.1). Male pups grew at a mean rate of about 124 grams per day (standard error = 10.5g) and females at mean rate of about 95 grams per day (standard error = 7.4g). Mean weights for each sex at each sampling period were about 1kg to 1.5kg greater than for the same time period last year.

Attendance ashore and foraging behavior: Attendance ashore of female fur seals was monitored using radio-transmitters (CEMP Standard Method C.1). Radio-transmitters were attached to 40 females during their perinatal periods (after parturition and before departing to sea for the first feeding trip) from 6 December through 12 December 1991. The CEMP Standard Method for estimating foraging trip duration (C.1) specifies that the first six feeding trips made by each female be used for estimation of the parameter. Thirty four of the 40 females completed 6 trips to sea without losing a pup. The mean duration of their first six trips combined was 94.36 hours (St.Dev. = 34.5; n = 204 trips)(Table 12.2).

The mean duration of the first six trips for females during the 1990/91 season was 115 hours. This year's estimate is approximately 11 hours less. Further analysis and inter-annual comparisons of foraging trip duration and of attendance behavior of female fur seals will be completed at the National Marine Mammal Laboratory (NMML).

Sixteen of the 40 females used for attendance studies were also instrumented with time-depth recorders (TDRs) to acquire a measure of foraging effort expended by females to raise their young. Fourteen TDRs were recovered from 16 January through 8 February 1992. Four females with TDRs were at sea during the small-area survey (Survey B) conducted by the *Surveyor* during Leg 1. The dive records will be analyzed at NMML for estimates of foraging effort and inter-annual comparisons.

Pup production: Daily counts of live and dead fur seal pups were obtained at North Cove and North Annex colonies to estimate the total number of births. The maximum number of live pups observed at North Cove was 229 on 27 December. The maximum number of pups at North Annex was 57 on 28 December. Prior to those dates, five dead pups were observed suggesting a minimum of 291 pups were born at the two sites.

In addition to North Cove and North Annex, there is a small fur seal colony (Big Boote) at a remote site on the northeast coast of Seal Island. At this site, 14 pups were counted on 14 January.

A census of a colony of fur seals similar in size to the North Cove colony was obtained on 9 February at Large Leap Island, approximately 1 km north of Seal Island. A total of 258 pups were counted by two observers making two counts each. This count includes an area of approximately 50 pups that was not counted in previous years.

Abundance, survival, and recruitment: Because the pup cohort is the only age class found ashore in its entirety during any particular census, pup counts provide the best estimate of the total number of breeding females in a colony and are therefore the best counts for inter-annual comparisons of colony size. The maximum number of pups observed at North Cove for this season (233; 229 live on 27 December plus 4 dead prior to this date) represents an insignificant decrease from last year's estimate of 239. The maximum count at North Annex was 58 (57 live pups on 28 December plus one dead pup observed previous to this date), an increase from 45 pups last year; the count of 14 pups at Big Boote was an increase from 7 pups last year.

An early arrival (2 December) of the Seal Island field team allowed documentation of the arrival and parturition of most of the population of breeding females at North Cove and North Annex. On 2 December 1991, 38 pups were recorded at North Cove and two pups at North Annex. The daily pup counts obtained for monitoring colony size will also provide estimates of the date of peak pupping and the rate of pup mortality.

Predation by leopard seals, a major source of pup mortality, does not occur until pups begin entering the water, usually around the time the last females are giving birth for the season. The last observed birth occurred at North Cove on 9 January, but prior to that date the last observed birth was 28 December. Leopard seal predation at North Cove, during the period monitored this year, was similar to that observed last year but less than in 1989/90.

Leopard seal predation has not been observed at North Annex, probably because intertidal areas frequented by pups there are usually inaccessible to leopard seals.

Counts of all fur seals present were made at weekly intervals in a standard census area (all easily accessible coastline from North Cove west around the island to, and including, Beaker Bay) (Table 12.3). Fur seals other than pups were counted by sex and reproductive status resulting in five general sex/age class categories: pups, adult females, adult males with females, adult males without females, and sub-adult males.

Daily observations were made of fur seals tagged in this and previous years to assess survival and recruitment to the breeding population. Of the 125 tagged female fur seals observed in the 1990/91 season at Seal Island, 104 were observed on Seal Island this season, 93 (89%) of which were observed with pups. In addition to these females, one female tagged in the 1990/91 season with a pup was observed at Large Leap Island on 9 February but had not been observed at Seal Island. Thirty-one females were added to the tagged population of female fur seals on Seal Island this year.

Twenty-six fur seals tagged as pups since 1986/87 on Seal Island were observed this year (Table 12.4). In addition, two tagged subadult male fur seals not tagged on Seal Island were observed, an orange small Allflex tag 312, and a green small Allflex with the number worn off. Between 29 January and 27 February, 201 pups were tagged with rounded-post monel flipper tags.

Diet: Fur seal feces were collected at bi-weekly intervals. Each sample consisted of 10 scats from each sex. The scats were put in frozen storage on board *Surveyor* for analysis of prey remains at NMML.

Abundance of other pinnipeds: Abundances of other pinniped species ashore on Seal Island were monitored by conducting weekly censuses (Table 12.5).

12.3 Tentative conclusions: Measurements of pup growth and attendance of females with pups seem to indicate better conditions for females rearing offspring in 1991/92 than in previous years. Statistical significance of the difference in the mean duration of the first six foraging trips of females (94 hours this year versus 115 hours in 1990/91) remains to be shown by analysis of data in Seattle. Increased mean pup weights, however, clearly show conditions were better in 1991/92 for fur seals than in the previous year. Comparison of these results with those from the concurrent studies of krill abundance and distribution near Seal Island, and with results from similar studies in previous years, may indicate whether prey were more available to fur seals in 1991/92 and, if so, whether the increased availability was due to changes in prey abundance, distribution, or some other factor.

Table 12.1 Mean weights, standard deviations, and sample sizes of male and female fur seal pups weighed during 5 sampling intervals from 30 December 1991 - 27 February 1992.

	Sampling Dates				
	30 Dec- 1 Jan	13 Jan- 15 Jan	29 Jan- 30 Jan	12 Feb- 13 Feb	26 Feb- 27 Feb
Males:					
mean wt.(kg)	9.43	11.44	14.07	15.21	16.49
std.dev.	1.48	1.73	1.71	2.05	1.86
n	53	54	55	46	42
FEMALES:					
mean wt.(kg)	8.30	9.57	11.73	12.58	13.67
std.dev.	1.24	1.19	1.25	1.22	1.62
n	47	46	45	54	55

Table 12.2 Mean duration of trips, standard deviation, sample size, maximum, and minimum trip lengths for the first six trips to sea for 34 female fur seals with pups at North Cove, Seal Island, 1991/92.

Trip #	N	Mean (h)	St.Dev.	Maximum (h)	Minimum (h)
1	34	101.13	37.1	199.6	37.9
2	34	114.34	35.0	169.8	34.9
3	34	116.23	27.2	180.6	66.0
4	34	85.41	28.7	158.6	8.9
5	34	77.80	22.6	125.9	17.9
6	34	71.25	28.1	160.7	22.9
All 6	204	94.36	34.5	199.6	8.9

Table 12.3 Weekly counts of antarctic fur seals, by sex and reproductive status, at Seal Island, Antarctica, 1991/92. These counts were made in a standard census area (which excludes the small fur seal rookery at Big Boote on the north coast of the island).

Date	Pups	Adult Females	Adult Males with females	Adult Males without females	Subadult Males
8 Dec	138	145	27	64	4
15 Dec	237	195	32	65	7
22 Dec	263	144	36	58	11
29 Dec	261	111	25	47	11
5 Jan	277	105	24	35	24
12 Jan	253	171	17	23	37
22 Jan	240	209	13	76	62
28 Jan	202	253	19	68	17
4 Feb	175	262	26	149	39
11 Feb	147	235	37	189	118
18 Feb	151	280	40	473	120
27 Feb	159	212	25	217	95
3 Mar	137	205	40	285	148

Table 12.4 The numbers of known-aged fur seals observed on Seal Island, 1991/92. Fur seal pups have been tagged every season on Seal Island beginning in 1986/87.

Cohort	Males	Females	Total
1986/87	3	4	7
1987/88	13	5	18
1988/89	8	8	16
1989/90	0	0	0
1990/91	3	4	7

Table 12.5 Weekly counts of pinnipeds other than antarctic fur seals at Seal Island, Antarctica, 1991/92.

Date	Leopard Seals	Weddell Seals	Elephant Seals
8 Dec	0	6	53
15 Dec	0	4	49
22 Dec	0	3	38
29 Dec	0	1	40
5 Jan	0	2	28
12 Jan	0	4	13
22 Jan	0	0	6
28 Jan	0	1	6
4 Feb	0	3	7
11 Feb	0	3	9
18 Feb	0	1	8
27 Feb	0	6	11
3 Mar	0	3	8

13. Seabird Research at Seal Island, Antarctica During 1991/92; submitted by D.A. Croll, J.K. Jansen, and S.W. Manley, National Marine Mammal Laboratory.

13.1 Objectives: Seabirds have been shown to serve as useful monitors of offshore prey resources. This is particularly true during the breeding season when the birds must return to their nest sites, limiting the area over which the birds may forage. In addition, the presence of birds on their breeding sites provides access for investigators to monitor various parameters of breeding and foraging that can serve as indices of offshore prey availability. Five species of seabird breed on Seal Island: chinstrap penguins (*Pygocelis antarctica*), macaroni penguins (*Eudyptes chrysolophus*), cape petrels (*Daption capensis*), Wilson's storm petrels (*Oceanites oceanicus*), and kelp gulls (*Larus dominicanus*). Southern giant petrels (*Macronectes giganteus*) breed on adjacent islands. Penguins are particularly useful for monitoring purposes. During the breeding season, they are tied to one location ashore where they return repeatedly throughout a 4 to 5 month period. Being flightless seabirds, they are limited in the distance they are able to forage from the breeding site. Therefore, aspects of their behavior and ecology reflect biotic and abiotic conditions adjacent to their land-based breeding areas. The principal research objectives for the 1991/92 field season were:

(1) To monitor the breeding success, fledgling size, reproductive chronology, foraging behavior, diet, abundance, survival, and recruitment of chinstrap and macaroni penguins according to CCAMLR Ecosystem Monitoring Program protocols (CEMP),

(2) To conduct directed research on chick growth and condition, and seasonal patterns in the diving behavior of chinstrap to assess changes in foraging behavior and effort as the breeding season progresses,

(3) To assess the reproductive success, survival, and recruitment of cape petrels,

(4) To measure the food load delivery to dependent chicks contemporaneously with foraging effort,

(5) To measure intra-annual differences in foraging effort in breeding chinstrap penguins,

(6) To initiate a feasibility study of the winter foraging behavior and distribution of chinstrap penguins,

13.2 Accomplishments:

Reproductive success and chronology: Breeding success was estimated according to CEMP Standard Methods A.6.B. (observations of 100 nest plots) and A.6.C. (discrete counts of colonies). Method A.6.B. is designed to determine the number of chicks raised to the creche stage for a set of individual nests. Rectangular plots of individuallyidentified chinstrap nests each were marked by stakes in 2 colonies (124 and 113 nests in the North Cove and Parking Lot study plots, respectively). Thirty-one macaroni penguin nests at Mac Top were also identified, of which 26 were monitored. These nests were observed every other day from a blind using a spotting scope (without entering the colony), and the number of incubated eggs or brooded chicks was recorded. Overall, of the chinstrap nests active at the commencement of observations (17 and 13 of December for the Parking Lot and North Cove plots, respectively), a total of 1.5 chicks/active nest were raised to creching at the Parking Lot plot, while 1.3 chicks/active nest reached the creche stage at North Cove.

These plots were also used to determine the chronology of penguin reproductive events at Seal Island through creching (Table 13.1). Chinstrap hatching began on 23 December; the rate of hatching peaked on 29 December and 27 December and was completed by 13 January and 7 January in the North Cove and Parking Lot study plots, respectively.

Hatching of macaroni chicks began on 25 December; hatching rate peaked around 29 December and was completed by 4 January. Macaroni creching began on 19 January and was completed by 27 January. Fledging began on 18 February and was completed on 27 February. The number of macaroni chicks/active nest raised to creching at Mac Top was 0.80; 23 of these chicks survived to fledging, giving a fledging success rate of 0.74 fledglings/active nest.

Upon completion of creching, the number of creched chicks was counted every other day in colony 66 (a colony of about 300 nests) to provide an estimate of mean date of fledging. Fledging began on 15 February; the fledging rate peaked around 21 February and was completed by 5 March.

Foraging Behavior: The duration of foraging trips was monitored to determine the amount of time at sea required by breeding adults to meet their own energetic needs and procure food for chicks, serving as an indicator of foraging effort and prey availability (CEMP Standard Method A.5.). Forty adult chinstrap penguins were equipped with radio transmitters (40 nests with one member of each nest equipped with transmitters) to monitor their presence ashore. An automatic scanning radio receiver and data logger recorded the attendance of radio-tagged birds within 15 minutes of arrival or departure. These nests were checked regularly for survival of chicks.

To provide detailed information on chinstrap penguins' diving behavior at sea, and how that behavior may change with the progression of the breeding season, a total of 42 chinstrap penguins were equipped with time-depth recorders (TDRs) which recorded dive profiles and time ashore: 16 during incubation, 12 during the early guard stage, 6 during the late guard stage, and 8 during the creche stage. The deployments made during the creche stage were timed to coincide with a small-area acoustic survey of offshore krill distribution. Of these deployments, 36 records were obtained. The dive records will be analyzed at NMML for estimates of foraging effort and inter- and intra-annual comparisons.

Diet: Between 21 January and 15 February 1992, a total of 30 stomach content samples was collected from breeding chinstrap penguins (CEMP Standard Method A.8.). The sampling schedule was divided into six 5-day collection periods. Adult birds were captured immediately upon returning to the colony after feeding trips to sea and weighed, measured (bill length, bill depth, and wing length), and banded prior to sampling. Stomach samples were obtained by lavaging with warm water. Prior to being released after lavaging, the birds were dyed with a yellow picric dye (to ensure that the bird was not handled again during the season).

Samples were sorted to remove otoliths and other prey hard parts in preparation for preservation and transport to NMML for further detailed analysis. As in past seasons, preliminary analyses have indicated krill as the major prey species.

Abundance, survival, and recruitment: The number of breeding pairs of all penguin colonies on the island was counted. The census was made after the completion of egg laying. All birds lying down in some sort of nest structure were assumed to be occupying a nest site, and were thus considered breeding. Large colonies (3, 4, 14, 25, 26, 58, and 61) were counted from photographs. The total number of chinstrap pairs nesting in 91/92 was estimated at 22,800. This number is approximately 45% higher than the number of birds counted the previous year. A total of 254 pairs of macaroni penguins attempted to breed on Seal Island in 1991/92; 13% fewer nests than recorded in the previous year.

According to CEMP Standard Method A.6.C., three censuses were made of 10 geographically discrete chinstrap colonies undisturbed by other activities. The number of nests with incubated eggs was counted near our arrival date, some time after laying was complete. When hatching was complete, the number of nests with chicks and the number of chicks in each nest was counted. When creching was complete, the total number of chicks in each colony was counted. Three replicate counts were made of each colony on the same day. If one of the three counts differed by more than 10% of any other count, a fourth count was made. The mean and standard deviation of the three (or four) counts was computed as an estimate of the parameter (Table 13.2). Each of the four macaroni penguin colonies was also censused (Table 13.3).

To estimate annual survivorship and recruitment into the breeding population, 2000 chinstrap and 75 macaroni penguin chicks were banded. By resighting banded birds in subsequent years, an estimate of age specific annual survival and recruitment can be calculated. Both systematic and opportunistic surveys to resight banded birds were conducted throughout the season.

Growth and condition: The growth rates of chinstrap penguin chicks were monitored by measuring the weight, culmen length, culmen depth, wing length, and noting the status of juvenile plumage molt every 5 days for 8 time periods between 6 January and 12 February at colony 4. Prior to creching, chicks numbering no less than 50 contained in at least 30 nests were measured during 5 sampling periods. After creching, a total of 75 chicks was measured per sampling period. After handling, chicks were dyed to avoid sampling them more than once during the season. Mean chinstrap chick weight peaked at 3.4kg on 7 February (Figure 13.1).

Following the initiation of chinstrap penguin fledging on 15 February, daily samples of fledglings present on Beaker Bay were weighed (CEMP Standard Method A.7.A.) until the completion of fledging, about March 4. A total of 264 fledglings were weighed and measured. Average (±sd) fledgling measurements were: weight 3.1kg (±0.37); culmen length 43.25mm (±2.62); culmen depth 14.79mm (±1.00); wing length 114mm (±5).

Macaroni chick weight, culmen length, culmen depth, and wing length were measured and the status of juvenile plumage molt was noted when banding chicks just prior to fledging. Mean (± sd) weights at this time were 3.3kg (±0.5), culmen length and depth were 44.49mm (±3.66) and 16.84mm (±1.19), respectively, while mean wing length was 109mm (±5).

Food Load Delivery to Chicks: Diving behavior and diet of chinstrap penguins breeding on Seal Island have been monitored each year on Seal Island since 1987. These data have provided an estimate of foraging effort and prey composition. In an effort to correlate these parameters with prey capture rates, the food load delivery to chicks was measured through continuous monitoring of nest mass. When coupled with diving behavior and diet, this information will significantly add to an assessment of the prey requirements and catch per unit effort of chinstrap penguins.

Three nests were selected for monitoring. As adults returned to the nest to feed their young, their mass was automatically recorded using an electronic balance/data acquisition system. The automatic weighing system consisted of an electronic balance unit housed in a water proof box. This unit was placed underneath an existing nest of chinstraps guarding chicks. The nest was temporarily displaced, a small area was excavated, and the balance unit with a simulated nest surface was placed in the excavated area. The chicks were replaced on the new surface. Each nest was connected to a central data acquisition unit located within the North Cove blind. The weight of each of the nests was logged every 30 minutes or upon arrival or departure of adults. The nest, its contents and adult arrival or departure times were continuously monitored visually from the blind. The chicks of these nests were measured and weighed at the start and conclusion of the experimental period.

Both adults of each nest were equipped with Wildlife Computers Mk 4.5 dive recorders. This will allow a measurement of daily foraging effort to be correlated with food load delivered to the nest. The results of these measurements will be analyzed at the National Marine Mammal Laboratory in Seattle.

Cape Petrels: The breeding success of accessible cape petrel nests was estimated by surveying nests 5 times during the season, approximately every two weeks. The status of nests was recorded (occupied but empty, unoccupied and empty, incubated egg, attended chick, or unattended chick). Nesting success was estimated at 0.93 chicks/active nest on 10 February. A total of sixty-nine petrel chicks were banded, weighed, and measured (mean weight (±sd) 0.57kg (±0.06), culmen length 29.52mm (±1.82), wing length 195mm (±19). Material regurgitated by chicks during banding indicated that most chicks were being fed krill.

Winter Foraging Behavior and Distribution: The foraging behavior of chinstrap and macaroni penguins has been studied on Seal Island since 1987/88. Through the use of time-depth recorders, we have learned a great deal about foraging effort, location of prey in the water column, and diurnal patterns in foraging during the breeding season. However, little is known about the foraging behavior of these animals during the remaining 8 months of the non-breeding season. Information about this portion of the birds' life cycle is essential if we are to adequately understand the relationship of penguins and prey resources. A study was initiated to test the feasibility of attaching TDRs equipped with location sensors to penguins during the non-breeding season.

A total of 5 adult, known breeding penguins, which had completed their annual molt, was selected on Seal Island in colony 72. Dummy TDRs (epoxy blocks of the same dimensions as data-logging TDRs) were attached to the feathers on the dorsal surface of the birds using 5-minute epoxy and plastic electric cable ties and released for the non-breeding season. Upon the return of the field team in 1992/93 to Seal Island, we will search for these birds. This will provide an estimate of the likelihood of recovering a penguin with an attached TDR that has been at sea throughout the non-breeding season.

13.3 Preliminary Conclusions: Preliminary analyses indicate that the number of chinstrap penguins and cape petrels attempting to breed on Seal Island was the highest recorded to date. The number of chicks that hatched was also very high. This would indicate that conditions prior to the initiation of breeding and during egg laying and incubation were exceptional. The survival and growth of chicks were also slightly higher than that observed in 1990/91. We would tentatively conclude that the exceptional conditions found earlier in the season may have persisted through the guard and creche stages. However, the size and weight of fledglings in 1991/92 were similar to that observed in 1990/91. This may indicate that prey availability was reduced during the later portion of the breeding season. The significance of these observations awaits further analyses in Seattle. Cape petrel reproductive success was particularly high during the 1991/92 season. More petrels attempted to breed, and most of the chicks that hatched survived to fledging. Further laboratory analyses of penguin foraging behavior patterns and diet should help to elaborate on these conclusions.

Table 13.1 Nesting chronology of chinstrap penguins at Parking Lot study plot on Seal Island, 1989/90 through 1991/92.

	1989/90	1990/91	1991/92
Peak Hatching	23 December	26 December	27 December
Start Creching	20 January	22 January	23 January
Start Fledging	5 February	16 February	19 February

Table 13.2 Summary of breeding success censuses of chinstrap penguins, Seal Island, 1991/92.

Completion of Egg Laying

Date	Colony	Mean	SD	N
12/22	9	314.0	22.8	4
12/22	21	86.7	0.6	3
12/22	24	14.0	0	3
12/22	31	275.7	3.1	3
12/22	32	43.0	1.7	3
12/22	33	100.3	1.5	3
12/22	42	172.0	6.9	4
12/22	51	38.3	1.3	4
12/22	54	226.3	7.8	4
12/22	66	235.3	7.6	3

Post Hatching

Date	Colony	Mean	SD	N
1/6	9	484.7	16.1	3
1/6	21	114.7	2.5	3
1/6	24	20.0	0	3
1/6	31	408.3	6.8	3
1/6	32	68.0	2.4	3
1/6	33	148.3	1.7	3
1/6	42	256.3	5.4	3
1/6	51	64.0	0	3
1/7	54	301.7	3.9	3
1/6	66	292.0	4.3	3

Table 13.2 Continued

Completion of Creching				
Date	Colony	Mean	SD	N
2/9	9	345.7	4.9	3
2/9	21	82.3	0.6	3
2/9	24	16.0	0	3
2/9	31	268.0	2.6	3
2/9	32	54.7	0.6	3
2/9	33	106.7	2.9	3
2/9	42	183.0	2.6	3
2/9	51	51.0	0	3
2/9	54	256.3	0.6	3
2/9	66	252.7	2.5	3

Table 13.3 Census results for macaroni penguins at the conclusion of egg laying, completion of hatching, and completion of creching at Seal Island, 1991/92.

Completion of Egg Laying

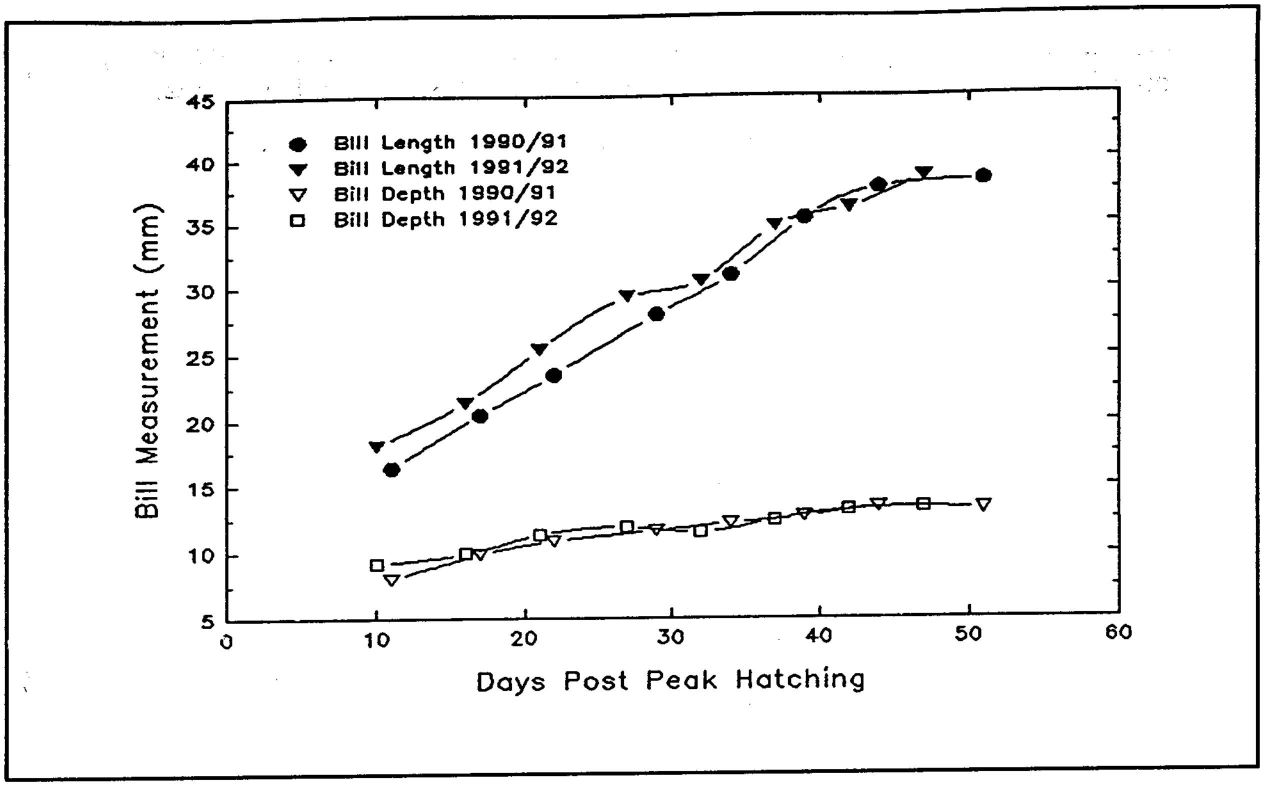
Date	Area	Area Name	1 Egg	1 Chick
12/22	4	Mac Top	28	0
12/22	31	Mac Peak	57.7	0
12/22	71	Macaroon	63.7	0
12/22	74	Macadamia	102.3	0
12/22	61	Macito	3	1
		Total	254.7	1

Completion of Hatching

Date	Area	Area Name	1 Egg	1 Chick
1/14	4	Mac Top	3	23
1/13	31	Mac Peak	2	52
1/13	71	Macaroon	2	53.7
1/14	74	Macadamia	1	98
1/14	61	Macito	1	3
		Total	9	229.7

Completion of Creching

Date	Area	Area Name	1 Egg	1 Chick
1/27	4	Mac Top	0	24
1/27	31	Mac Peak	0	52
1/27	71	Macaroon	0	53
1/27	74	Macadamia	0	74.5
1/27	61	Macito	0	4
		Total	0	207.5



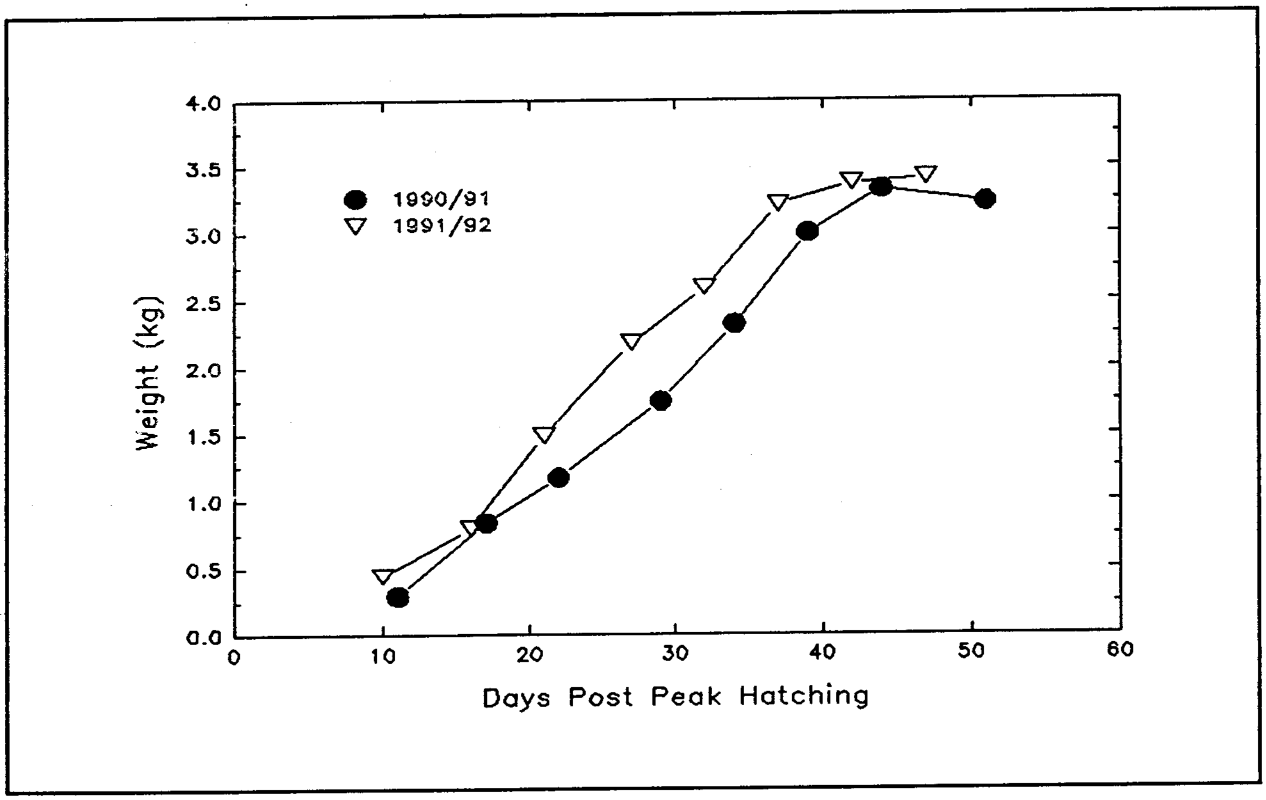


Figure 13.1 Growth of chinstrap penguin chicks at Parking Lot study plot on Seal Island 1991/92.

14. Seabird research undertaken as part of the NMFS/AMLR ecosystem monitoring program at Palmer Station, 1991-1992; submitted by William Fraser, Old Dominion University.

14.1 Objectives: Research at Palmer Station focuses on aspects of the ecology of Adelie penguins that are complementary to the scope of research and objectives outlined by the CCAMLR Ecosystem Monitoring Program (CEMP). CEMP has recommended that directed research and monitoring activities be conducted at several integrated study areas in the Southern Oceans with access to large populations of krill-eating predators. Palmer Station is one of two sites on the Antarctic Peninsula where long term monitoring of seabird populations is being undertaken in support of U.S. participation in CEMP. Our objectives during 1991-1992, the fifth season of field work at Palmer Station were to: (1) determine Adelie breeding success, (2) examine how present and past indices of Adelie breeding success relate to a true measure of breeding success, (3) gather information on Adelie diet composition and meal size, (4) determine Adelie chick weights at fledging, (5) determine the amount of time breeding adult Adelie penguins need to procure food for their chicks, (6) band a representative sample (1000 chicks) of the Adelie chick population, (7) determine adult Adelie breeding chronology, and 8) explore the feasibility of adding more of the Standard Methods to the suite of data now being collected at Palmer Station.

14.2 Accomplishments and Field Schedules: Field work at Palmer Station was initiated on 17 October 1991 and terminated on 7 March 1992. The early start date was aided by joint funding from the National Science Foundation's (NSF) Division of Polar Programs. NSF recently chose Palmer as a Long Term Ecological Research (LTER) site, and has committed long-term funding and logistics support to an ecosystem study in which Adelie penguins represent one of two key upper trophic level predators selected for research. As a result of this cooperative effort between the National Marine Fisheries Service (NMFS) and NSF, the length of field seasons at Palmer will effectively be extended by nearly three months. Palmer will thus be the first U.S. AMLR study area to provide data on Adelies during the entire course of their 5-month breeding season. Field work schedules, and activities related to the above cited objectives were as follows:

1. Adelie breeding success.

Until this season, breeding success in Adelie penguins had been estimated by using indices based on chick production per colony, the number of active nest sites in early January and the ratio of 1-and 2-chick broods (see below). A true measure of breeding success, that is, the number of chicks reaching creche age per breeding pair, had not been previously obtained due to the late start of the field season and the subsequent inability to determine the number of breeding pairs and the fate of their eggs and chicks early in the season. This year, in contrast to past seasons, a 100-nest sample was followed on Humble Island from clutch initiation to creche. Adelies creched 1.39 chicks per pair, suggesting relatively high productivity in 91-92. The major cause of mortality was nest flooding and the subsequent loss of eggs.

2. Breeding success and the use of indices.

As in past seasons, two indices of breeding success were determined. On 9 January, the proportion of 1 and 2 chick broods was assessed at 51 colonies in 5 different rookeries; on 26 January these and other colonies were censused to assess chick production. Of the 3020 active territories examined, 70.5% were 2-chick broods. Production at selected colonies totaled 6388 chicks (4025 active territories), which suggests a per-pair productivity of 1.59 chicks, or 0.20 chicks more than the more accurate measure obtained above. This difference does not appear to be large enough to negate the potential usefulness of these indices.

3. Diet composition.

Diet studies were initiated on 15 January and terminated on 19 February. During each of the 8 sampling periods, 5 adult Adelies were captured and lavaged (stomach pumping using a water off-loading method) as they approached their colonies to feed chicks on Torgersen Island. All birds (N=40) were subsequently released unharmed. The resulting diet samples were processed at Palmer Station. A nearly complete absence of all prey other than krill (*Euphausia superba*) characterized the 91-92 samples. These krill were larger than in previous seasons, averaging 40-45mm in length.

4. Chick fledging weights.

Data on Adelie chick fledging weights were obtained between 7-25 February at beaches near the Humble Island rookery. During this interval, 391 chicks were weighed and released. Peak fledging occurred on 19 February; average fledgling weight was 3.2kg.

5. Length of foraging bouts.

Radio receivers and automatic data loggers were deployed at the Humble Island rookery between 15 January and 23 February to monitor presence-absence data on 36 breeding Adelies carrying small radio transmitters. These transmitters were glued to adult penguins feeding 10-14 day old chicks. An additional 3 transmitters available to us were not functioning properly and were not deployed. Analysis of the data has not yet been accomplished due to the size of the databases obtained. These results will be presented as part of the final report being delivered at a later date.

6. Chick banding.

One-thousand Adelie chicks were banded as part of long-term demographic studies at AMLR colonies on Humble Island. This effort was accomplished during the first week in February to accommodate differences in chick size at the various colonies. These differences in size were due to variations in breeding chronology between colonies due to significant differences in the amount of snow cover early in the breeding season. The presence of birds banded in previous seasons was also monitored during the entire field season on Humble Island as part of these demographic studies.

7. Adult breeding chronology.

As last season, a 100-nest sample was established on Humble Island to assess the chronology of breeding events, with relevant data being obtained every 1-3 days as weather permitted from 17 October to 7 March. Relative to last season, peak activity in a variety of breeding events occurred 3-5 days later in 91-92, although it is now clear that there are large variations between colonies due primarily to the amount of snow cover.

8. Feasibility studies.

Because of the longer field seasons that can now be undertaken at Palmer Station, great potential exists for adding more of the CEMP Standard Methods to the suite of data being collected. In 91-92, we successfully added Procedure B (chicks raised per breeding pair) to Standard Method A6.2 (breeding success). Procedure B, perhaps the most labor intensive of all the Standard Methods, will be implemented each season to complement data being obtained with Procedure A (chick counts) and the proportion of 1- to 2-chick broods. Procedure C (chicks raised per colony) was not successfully implemented this year due primarily to early season problems with access to the rookeries because of pack ice. For the same reason, Standard Method A2.2 (duration of the first incubation shift) was also not implemented. However, Standard Method A3.2 (breeding population size) was implemented and will become part of the suite of data collected at Palmer each season. Obviously, for these and the other methods discussed above, data collection was expanded to incorporate the months of October, November and December. This includes weather and other environmental data as well.

14.3 Preliminary Results: This season's measures of breeding success suggest that Adelie productivity was higher than last in terms of the number of 2-chick broods present, the number of chicks creched per colony and the number of chicks creched per pair. The factors responsible for this change are currently not known and must await further analysis of our data. As last year, the predominant component in the diets of Adelie penguins was the krill Euphausia superba. Noteworthy, was the fact that this season other prey were virtually non-existent in Adelie diets and krill size classes continued to emphasize the larger specimens (41-50mm). We currently cannot provide any information on the relative availability of krill between seasons based on telemetry data used to estimate the length of foraging intervals; analysis of these data is currently beyond the scope of this report due to the large size of the pertinent databases.

Mean Adelie chick fledging weights did not differ significantly from those evident last season (3.20 vs. 3.10kg). As last year, the fledging period again encompassed a 3-week interval (7-25 February), with peak fledging occurring on 19 February (vs. 16 February during 90-91). This 3-5 day delay in peak activity of this breeding event was typical of the chronology of other breeding events this season, suggesting some delay in the overall timing of breeding. The season was in general characterized by heavier than normal snowfall both before and after breeding got underway. From comparisons between colonies, it is clear that snow cover is potentially one of the greatest terrestrial determinants affecting the timing of breeding in this species.

14.4 Disposition of the data: No diet samples were returned to the U.S. for analysis as all work was successfully completed at Palmer Station. All other data relevant to this season's research are currently on diskettes in our possession and will be made available to the Antarctic Ecosystems Research Group coincident with the final report on this season's activities due in July.

14.5 Problems, Suggestions and Recommendations: This season, in contrast to others, was relatively problem-free at Palmer Station. Minor problems with the telemetry equipment were repaired on site, thus allowing this aspect of the research to achieve its full potential. All other procedures were successfully completed, and it is clear that several new Standard Methods can be added to the data being collected without taxing the available field and personnel resources. The only persistent problem at Palmer continues to be obtaining consistent access to AMLR colonies due to weather and pack ice, which tend to limit small boat (Zodiac) operations. As a result, Standard Methods that depend on predictable and consistent access to study sites are not likely to be successfully implemented at Palmer. We are continuing to investigate ways of obtaining data relevant to CEMP within the constraints imposed on us by Palmer's unique working environment, and will report potentially new alternatives to NMFS as they are found.